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Control room of central track-diagram interlocking at Würzburg central railroad station

More than 30 000 railroad switches and signals in all parts of the world are controlled from Siemens track-diagram interlockings that have been developed and produced by the Siemens Telegraph and Signaling Division along with a large variety of other railroad signaling equipment

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The Badalona (Spain) Steam Power Station

By Günter Eifert

One of the main problems confronting Spain's economy is the extension of the electrical power supply sources. The growing industrialisation, the increase in population, the gaining of new consumer classes and the rising standard of living have created a considerable demand for electrical energy especially in the northeastern part of the country, in the province of Catalonia. The numerous hydro-electric power plants can be utilized to a limited degree only during dry years. This makes it necessary to erect thermal power stations in the vicinity of area load centres to enable the power supply to be maintained during the dry periods.

Fig. 1 shows the power stations, transformer substations and the associated extra-high voltage system located in the area of the province of Catalonia and supplied by the Fuerzas Eléctricas de Cataluña S.A.

The new Badalona steam power station (Fig. 2) which was erected to the order of the Fuerzas Eléctricas de Cataluña S.A. directly on the Coast of the Mediterranean, north-east of Barcelona, is to help to meet the electrical power requirements of the province of Catalonia during the dry periods. When the hydro-electric power stations are loaded to the full installed capacity, it is to be used for improving the voltage conditions in the systems by operating the generating units as synchronous condensers. In addition to this, when the power plant is shut down, the associated 6-kV, 25-kV and 110-kV switching stations can be operated as transformer substations as part of the area transmission and supply system.

In 1955 the Siemens-Schuckertwerke were entrusted with the supply and erection of the mechanical and electrical equipment of the Badalona steam power plant. The contract also included the overall planning and the preparation of the civil engineering design, the construction work being carried out by the Sala Amat S.A., Barcelona, a Spanish civil engineering company. The initial stage of construction of the power station provides for two 34-MW turbo-sets and the second stage of construction for the installation of a 69-MW turbine-generator unit. The plant has been so designed that a further 69-MW set can be installed in a third stage of construction. The associated boiler plant can supply full load with both pulverized-fuel firing and oil firing. The necessary cooling water is taken from the sea. All the power plant equipment is designed for operation at any frequency from 47 to 51 cycles. The main factors underlying the design of the plant were ease and safety in operation and simplified stocking of spare parts. In view of these considerations standardized boiler and turbine designs were selected and provision was made to employ for the various stages of construction uniform and identical plant components as far as this was possible.

Location and general arrangement

The Badalona steam power station is located 10 km (6 miles) north-east of Barcelona and between the villages of San Adrian del Besós and Badalona. The site of the power plant extends in the southeast to the Mediterranean and in the northwest to the railway line from Barcelona to the Costa Brava (Fig. 3).

The power house is divided into four parallel bays. Each of the two boiler houses has two high-capacity boilers arranged in one row. The adjacent heavy-bunker bays house the coal mills, coal hoppers and coal feeders; they terminate towards the sea in a 50 m (160 ft) high structure where the service water and town water tanks are arranged. Located between the two boiler houses and heavy bunker structures is the control room and station service

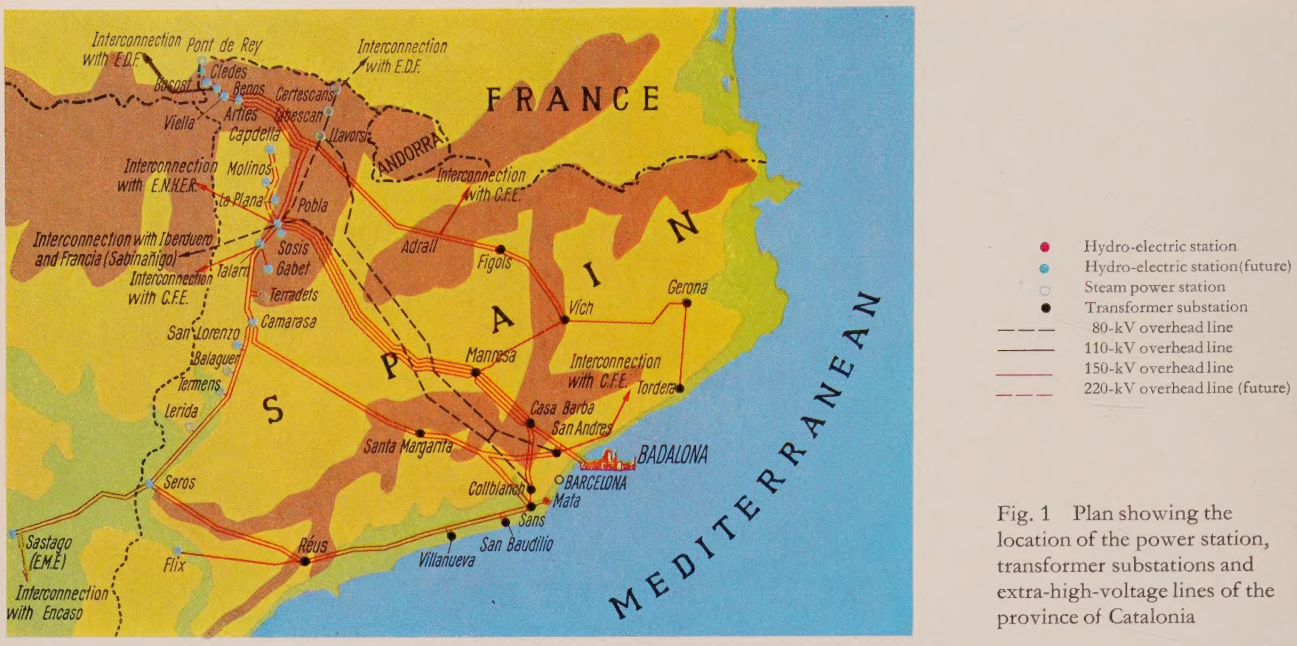


Fig. 1 Plan showing the location of the power station, transformer substations and extra-high-voltage lines of the province of Catalonia

building where the thermal control room, the electric control room, the battery rooms, the unit and station-service switchgear and transformers are installed. Parallel to the heavy bunker bays is the turbine house 110 m (360 ft) long and 22.80 m (75 ft) wide. Two 34-MW turbo-sets and one 69-MW set are arranged in line in the longitudinal direction, one boiler being associated with each 34-MW set and two boilers with the 69-MW set. The feed-heating and the evaporator plant are arranged parallel to the turbo-sets on the side of the heavy-bunker bay. The 110-m long 6-kV switching house is annexed directly on the southwest side of the turbine house; it contains the 6-kV switchgear and the relay boards for the 6-kV, 25-kV and 110-kV switching plants. The main operating floor of the power station is at elevation +13.80 m.

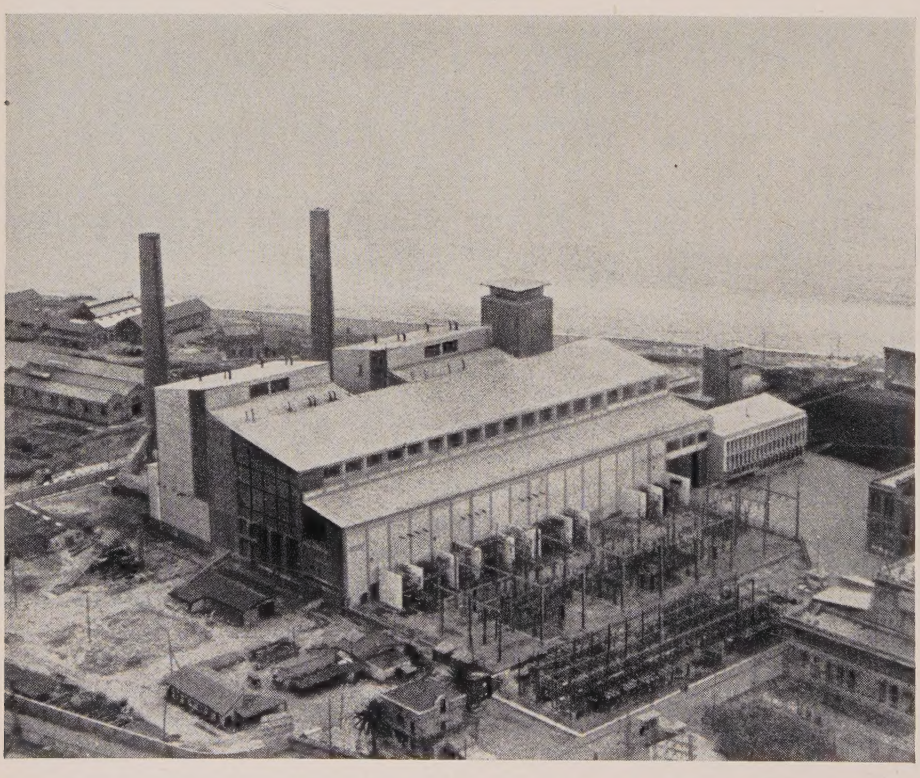


Fig. 2 View of the Badalona power station

Arranged in front of the outer wall of the 6-kV switchgear house are the 42.5-MVA generator transformers with the associaters regulating autotransformers and one 6.3-MVA station-service transformer for the 69-MW turbo-set. On the side opposite the transformers is the 110-kV outdoor-switching station behind which a 25-kV switching station is located. The ancillary buildings such as workshop and store, chemical water purification plant, laboratory and administration buildings are adjacent to the main building on the side facing the sea. Between

the power house proper and the sea are located the coal storage, fuel-oil storage tanks with the oil pump house and the intake structure. Stacks 60 m (200 ft) high, each common to two boilers, are arranged behind the two boiler houses and in between these two stacks is located the oil preheater house. In line with the stacks are two heavy-oil day tanks and a light-oil tank.

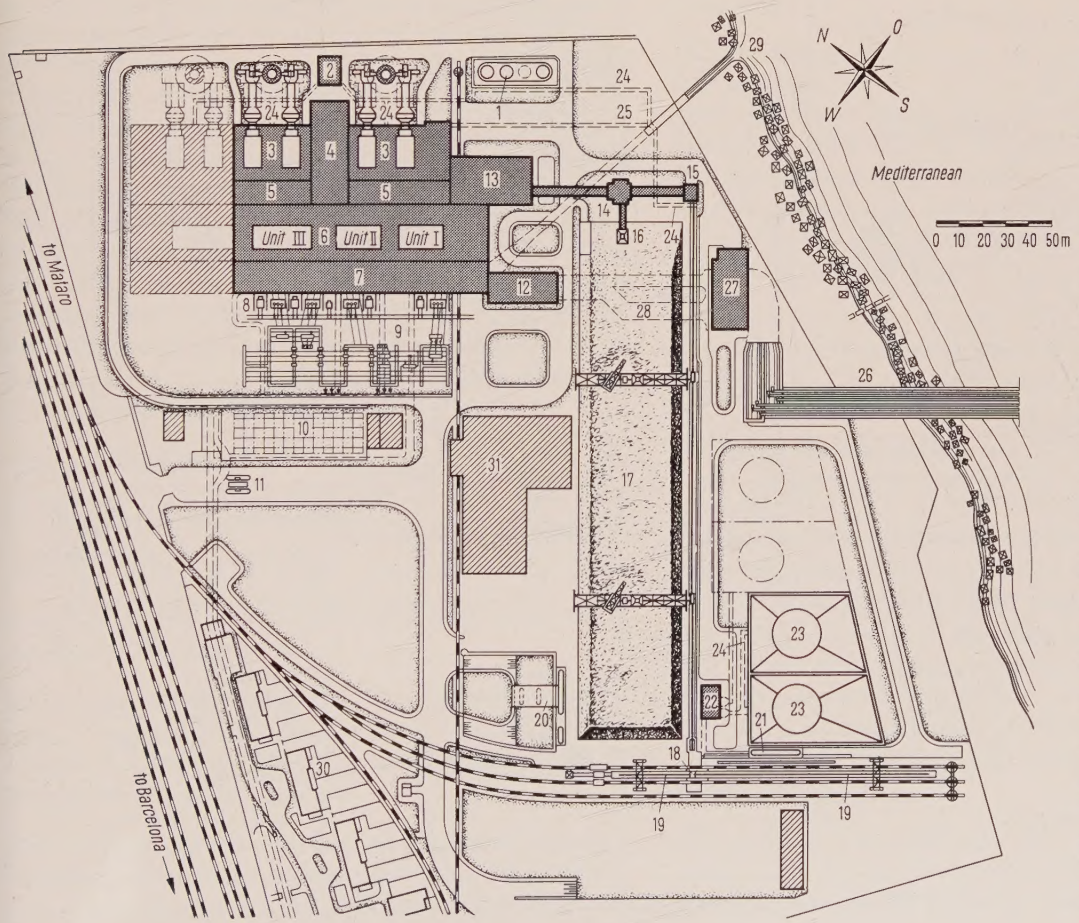
Fuel and water supply

The plant can be alternatively fired with coal or oil, which are transported overland. The coal storage has a capacity of 50,000 tons which is sufficient for one month's full-load operation at the present installed generating capacity. The maximum capacity of the coal handling plant is 180 tons per hour.

The coal received is unloaded from railway waggons or road trucks by means of two tower unloaders with grab buckets. The coal is crushed in a coal preparation station and transported by a longitudinal belt conveyor either to the power house or to the storage place. The storage site is covered by two mobile loading bridges with bucket cranes over its full length. From the longitudinal site conveyor the coal is reclaimed and transferred to the coal bunkers of the power plant at elevation +26.5 m by means of two inclined conveyors. The capacity of the coal bunkers is sufficient for round-the-clock operation at full load.

The fuel oil is passed from tank waggons or tank trucks to low-level tanks from which the transfer pump in the oil pump house pumps the oil to the two storage tanks each of 4,000 cu.m (880,000 Imp. gals) capacity or directly to the day tank each of which can take 200 tons of oil. This is sufficient for 20-hr. operation of each boiler. The pumps in the oil heater house draw the oil from the day tanks and pump it via the oil preheaters to the burners arranged in the boiler.

The full-load cooling-water requirements of the power station are about 20,000 cu.m (4,400,000 Imp. gals) per hour. The water required for condensing the steam, cooling the bearing oil of the turbine sets and for cooling the air or hydrogen coolant of the generators is taken in from the sea. The water is passed by siphonic action through several parallel pipe lines which run along a concrete bridge into a forebay in front of the intake structure. From here the cooling water is drawn in by pumps via a mechanical purification plant. Two half-load cooling-water pumps are provided for each turbo-set to force the water through a divided surface



1 Day oil tank
2 Oil preheater house
3 Boiler house
4 Control room and station service building
5 Heavy bunker bay
6 Turbine hall
7 6-kV switching house
8 Transformers
9 110-kV outdoor switching station
10 25-kV outdoor switching station
11 Weighbridge
12 Administration building
13 Workshop
14 Coal mixing plant
15 Coal tower
16 Emergency coal handling station
17 Coal storage
18 Coal preparation plant
19 Coal unloading station
20 Oil unloading station for tank trucks
21 Oil unloading station for tank waggons
22 Oil pump house
23 Fuel oil storage tanks
24 Fuel oil line duct
25 Pipe lines for water sluicing the ash
26 Cooling-water siphon lines
27 Intake structure
28 Cooling-water supply lines
29 Cooling-water outlet culvert
30 Flats
31 Old power station

Fig. 3 Site plan of the Badalona power station

condenser and a by-pass circuit with the oil and generator-coolers. The cooling-water pumps operate on the siphonic principle and the cooling water is returned to the sea via a discharge culvert at a distance of about 275 m (900 ft) from the intake point.

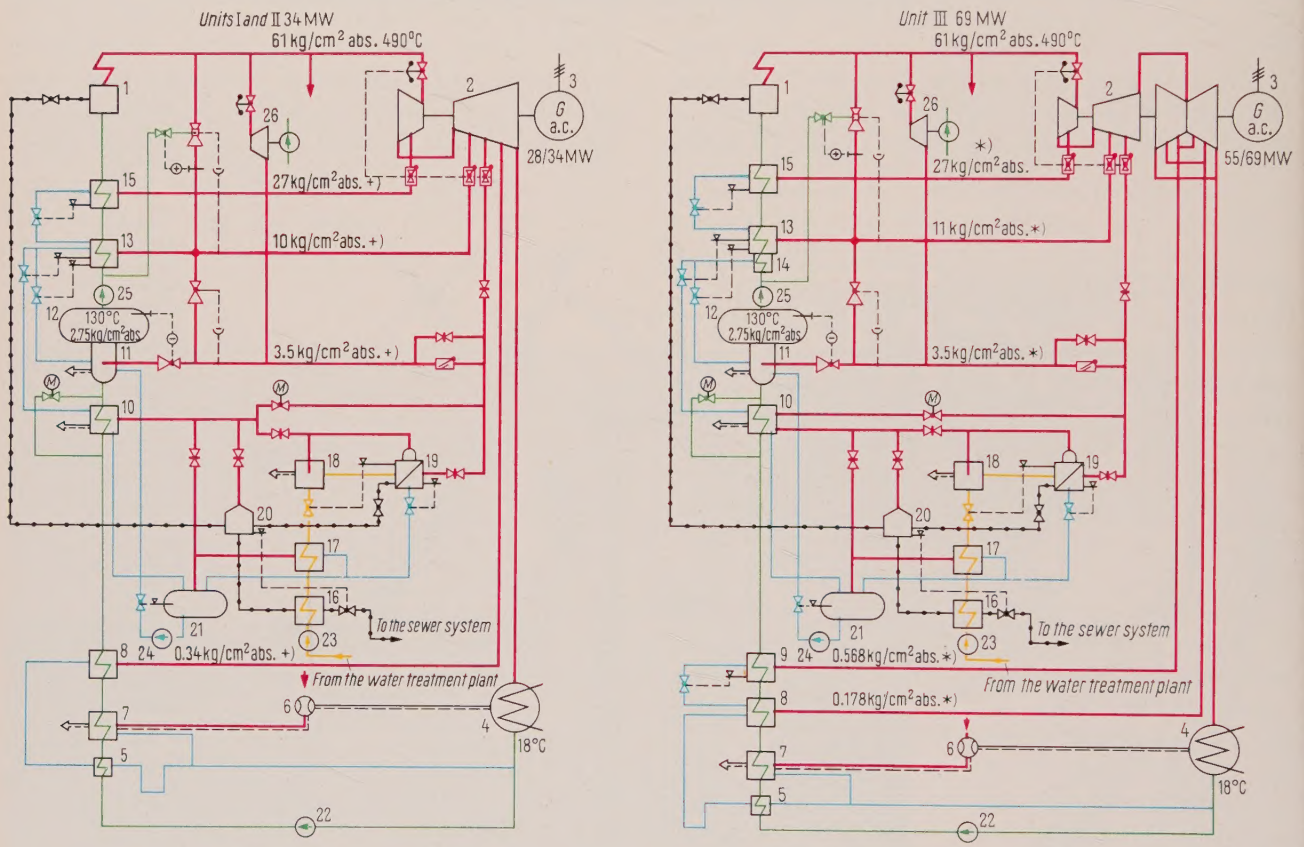
The make-up water is produced by evaporators. The evaporator capacity is 5% of the live-steam quantity of the particular unit. Two water treatment plants each of 16 cu.m (3,520 Imp. gals) per hour capacity serve to soften the evaporator feedwater. The raw water is tapped from the town water mains.

A closed service water circuit provides the cooling water for the bearings of the various auxiliaries such as boiler feed pumps, pulverizers, induced-draft fans, etc.

Heat flow diagram

The thermal part of the power station is designed on the unit principle. In the initial stage of construction one 145-tons/hr boiler and one 34-MW turbo-set, in the second stage of construction two 145-tons/hr boilers and one 69-MW turbo-set form together with the associated evaporator and feed heating plants one unit system. Fig. 4 shows the heat flow diagram for one 34-MW unit and for the 69-MW unit.

In selecting the live steam conditions account was taken of the requirements mentioned earlier in this article, which this power station has to fulfill. The superheater outlet steam conditions were therefore selected at 64 kg/cm² gauge, 500° C (910 psig, 932° F) corresponding to 60 kg/cm² gauge, 490° C (853 psig, 914° F) at the turbine stop valve, in order to achieve maximum utilization of the fuel heat content without reheating at the cooling water temperatures of normal 18° C (64° F) and maximum 28° C (82° F), with a maximum superheated steam temperature of 500° C (932° F) to be maintained. The boiler feed water of the 34-MW unit is heated to



+) *) *As measured in the turbine at rated output*

1 Boiler
2 Turbine
3 Generator
4 Surface condenser
5 Drain cooler
6 Steam-jet air ejector
7 Condensate cooler
8 Vacuo-heater
9 L.P. heater
10 Vapour condenser
11 Deaerating direct-contact heater
12 Feedwater tank
13 H.P. heater II
14 Condensed-steam cooler
15 H.P. heater I
16 Blowdown cooler
17 Softened-water preheater
18 Softened-water deaerator
19 Evaporator
20 Blowdown flash box
21 Distilled-water tank
22 Condensate removal pump
23 Softened-water pump
24 Distilled-water pump
25 Boiler feed pump
26 Standby boiler feed pump

Steam
Turbine condensate-Boiler feed
Condensate drain
Softened water
Blowdown
Control impulse
Air

Fig. 4 Heat flow diagram for one 34-MW unit and the 69-MW unit

220° C (428° F) by a four-stage feed heating plant at an optimum load of 28 MW and that of the 69-MW unit by five feed heaters at an optimum load of 55 MW, thus taking advantage of regenerative feed heating to the highest possible degree. The remaining steam quantity which continues to flow through the remainder of the turbine behind the extraction stages is reduced to the condenser pressure and condensed in the surface condenser. The condenser is evacuated by a steam-jet air ejector which is combined with a drain cooler. The turbine condensate available is forced by the condensate pump through the feed heaters of the 3rd, 4th and 5th feed-heating stage, that is, through the low-pressure drain cooler, low-pressure heater and vapour condenser into the deaerating direct-contact heater. The 69-MW unit is fitted with two low-pressure heaters. The evaporator and deaerating direct-contact heater are operated with steam bled from No. 3 extraction point and the high-pressure heaters I and II with steam from the No. 1 and No. 2 extraction points respectively. The vapour from the evaporator is condensed in the vapour condenser. A deaerating pressure of 2.75 ata (39 psia) corresponding to a constant mixing temperature of 130 °C (266 °F) is maintained in the deaerating direct-contact heater. The condensate drains for the low-pressure feed heating stages are passed to the surface condenser and those from the high-pressure heaters partly to the deaerating direct-contact heater and partly to the distilled water tank. The latter tank also receives condensate from the evaporating plant. A distilled-water pump draws condensate from the distilled-water tank and pumps it into the deaerating direct-contact heater. From the feedwater tank, the feedwater flows to the boiler feed pump which forces it through the cascaded high-pressure heaters into the boiler. Each boiler is fed by an electrically-driven and a steam-driven boiler feed pump of 182 tons/hr capacity each, the electric feedwater pump acting as the normal service pump. On failure of this pump due to loss in pressure in its suction pipe the steam-driven pump is automatically started up to supply the boiler with feedwater.

The units I and II can be interconnected via a live steam cross connection and a feedwater pressure line. This emergency connection makes it possible to operate any machine from any one boiler.

The feed heating plant is provided with direct-acting mechanical flow regulators.

When starting up the plant, the feedwater tank is used as start-up tank, which is then heated with de-superheated live steam of reduced pressure via a start-up station.

Before starting up the machine, the evaporator plant can likewise be put into operation by means of a special connection arrangement, a feature which is of particular importance when starting up the plant after long stand-still periods.

Mechanical equipment

Each of the two 34-MW units has its own high-capacity vertical-tube boiler with a steam raising capacity of 145 tons/hr. Two 145 tons/hr boilers are provided for the 69-MW unit. Each boiler is built for a design pressure of 75 kg/cm^2 gauge (1,066 psig) at a superheater outlet temperature of 500 °C (932 °F).

The boilers can be fired with both coal and oil. The net calorific value of the coal may be as low as 4,000 to 6,000 kcal/kg. This means that all coal grades available in Spain can be used with these boilers. As fuel oil Bunker C oil with a net calorific value of 10,200 kcal/kg is normally used. For pulverized fuel firing, each boiler is provided with 12 pulverized fuel burners which are arranged in three tiers in the corners of the furnace. In addition, 10 oil burners are provided on each boiler for oil firing and these are installed on the two side walls of the furnace. The boiler is lighted off with the four lower oil burners which are also suitable for operation with light oil. Three fuel oil pumps and one oil heating station are provided for each two boilers. Each boiler is furthermore equipped with three coal mills, a forced-draft fan, an induced-draft fan and a Ljungström air preheater.

During starting up, the steam of each boiler is passed to the feedwater tank via a start-up valve. Only small steam quantities which cannot be taken up by this tank are blown off above the roof into the atmosphere, so that the condensate losses are limited to a minimum. Under normal conditions the boiler is started up with light oil or fuel oil. The start-up steam quantity is then at about 10% of the full-load steam output.

As mentioned earlier, the first stage of construction of this power station provides for two 34-MW turbo-sets and the second stage for a 69-MW set. All machine sets are of the condensing type and are mounted in line parallel to the longitudinal axis of the turbine house on steel concrete foundations having low vibrational frequencies. The optimum load of each of the two two-cylinder turbines is at 28 MW and that of the large three-cylinder turbine at 55 MW. The live steam conditions of all three turbo-sets are 60 kg/cm^2 gauge, 490 °C (853 psig, 914 °F). While the 34-MW turbines are each fitted with four uncontrolled extraction stages, the 69-MW turbine has five uncontrolled extraction points. Each turbine set has a divided surface condenser, two cooling-water pumps, two condensate pumps and two steam-jet air ejectors.

The generators are two-pole three-phase synchronous machines of standard design which are direct-excited by a main and an auxiliary exciter. At turbine outputs of

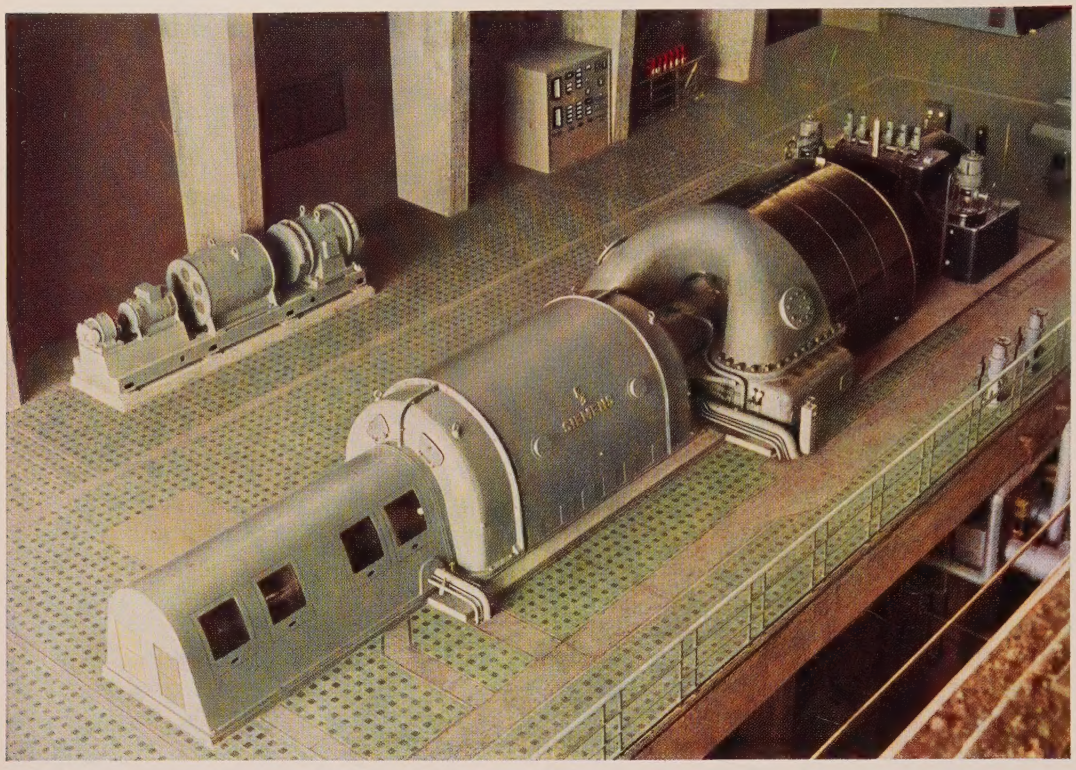


Fig. 5 34-MW turbo-set with associated motor-generator for synchronous condenser operation

34 MW and 69 MW the power factor is 0.8, which corresponds to 42.5 MVA and 86 MVA respectively. The two 42.5-MVA generators are air-cooled, while the 86-MVA generator is hydrogen-cooled. The two smaller generators are designed for a rated voltage of 6.3 kV and the large generator for 10.9 kV. All generators are equipped with automatic voltage regulators. For use as synchronous condensers the two 42.5-MVA generators are additionally provided with a.c./d.c. converter sets (Fig. 5).

The unit feed heating and evaporator plants are arranged alongside the turbo-sets between elevations +4.80 m and +13.80 m. Immediately adjacent to them are the feedwater tanks with the deaerating direct-contact heater and the boiler feed pumps.

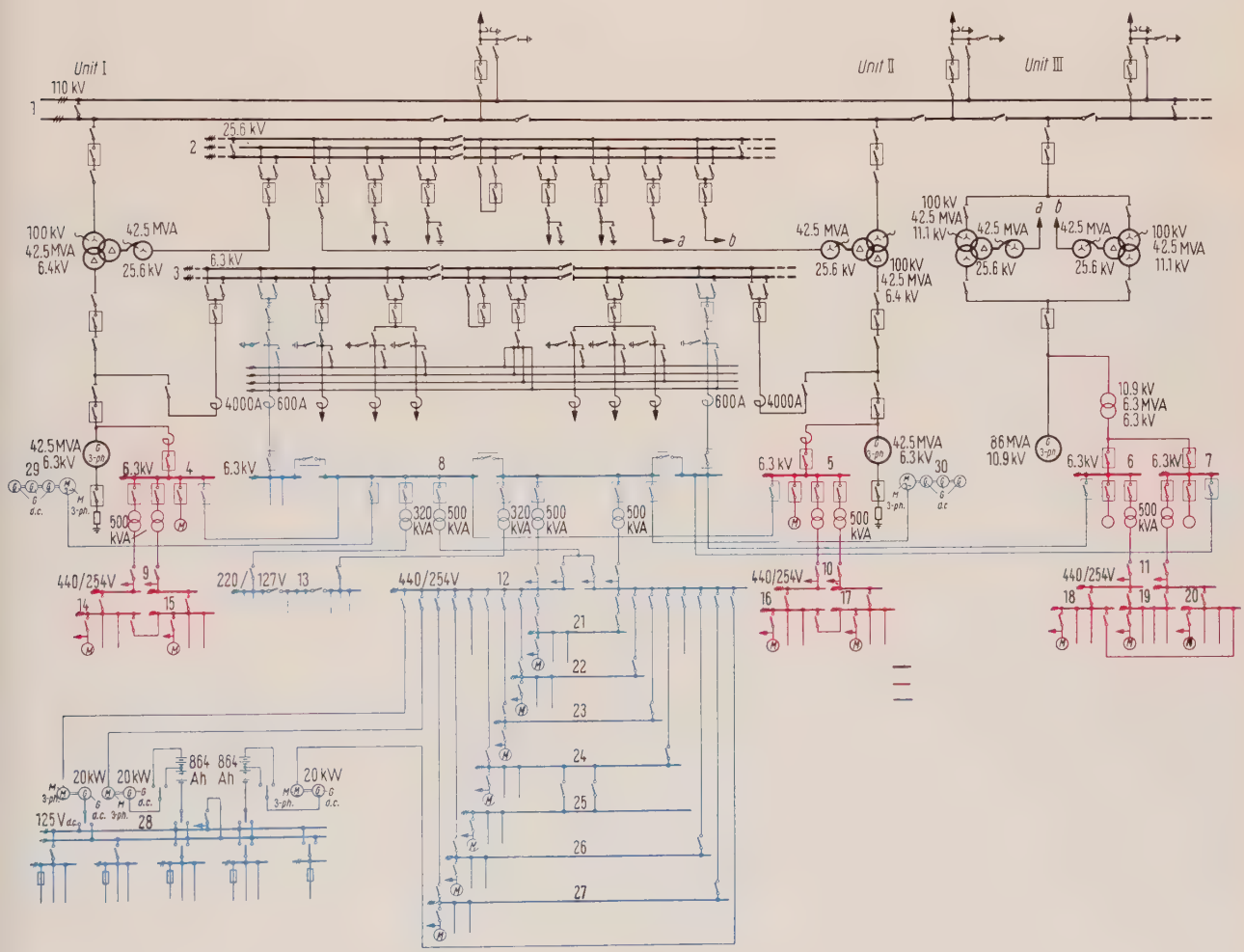
Electrical circuit arrangement

The load area of the power station is covered by the 110-kV system of the province of Catalonia and by a 25-kV and a 6-kV distribution system. While the two 42.5-MVA generators are directly connected to the bus of the 6-kV system and also via 42.5-MVA three-winding transformers to the busbars of the 110-kV and 25-kV switching stations, the 86-MVA generator supplies power via two 42.5-MVA three-winding transformers to the 110-kV and the 25-kV busbars. Connected between the three-winding transformers and the infeed points of the 25-kV switching stations are autotransformers each with a circuit rating of 42.5 MVA. The two feeders from the generators to the 6-kV switchgear are each provided with 4,000-A current-limiting reactors.

The power requirements for the auxiliaries are divided up unitwise in accordance with the thermal arrangement of the station. Each 34-MW unit has its own 6-kV main unit distribution system, which supplies all motors with ratings above 100 kW and two 500-kVA step-down transformers, one of which feeds the 440-V loads of the particular unit system. The energy required for the unit auxiliaries is tapped from the main connections between generator and three-winding transformer and fed via a 600-A current-limiting reactor to the unit auxiliary distribution system. In accordance with the number of boilers the 69-MW unit has two 6-kV unit auxiliary distribution boards which are likewise fed from the main connections between the 86-MVA generator and the two associated three-winding transformers via a 6.3-MVA station-service auxiliary transformer. The 6-kV and 440-V unit distribution systems supply all auxiliaries required for the safe operation of the particular unit. Since, however, various auxiliaries such as superheater steam valves, start-up valves, bearing-oil pumps, etc. must be ready for operation even in the case of failure of the unit auxiliary supply, these auxiliaries are d.c.-operated. The power required for starting up each unit is supplied from the 6-kV starting bus via a start-up switch associated with each unit system. The 6-kV starting bus is fed through two cable feeders from the 6-kV

system switching station via 600-A current-limiting reactors. The 6-kV switching station is, in turn, supplied from the 42.5-MVA generators or from the 110-kV or 25-kV switching station via the three-winding transformers. The starting bus also supplies the station service loads such as coal handling plant, fuel oil plant, intake structure, water treatment plant, lighting system, etc. in addition to the two motor-generator sets required for synchronous condenser operation.

The electrical circuit of the power station shown in Fig. 6 represents the optimum economical solution for the three possible types of operation, namely, generator, system and synchronous condenser operation. While in generating operation the power delivered by the generators is fed via the switching stations into the 6-kV, 25-kV and 110-kV systems, in pure system operation the energy is exchanged between the systems via the three-winding transformers. In synchronous-condenser operation, the turbines of the 34-MW sets are uncoupled and the generators brought up to synchronous speed with the aid of the motor-generator sets and the main exciters, which are then used as poney motors, and are connected as synchronous motors to the switching stations. Each of the 42.5-MVA generators is designed for a maximum reactive output of 24,000 kVAr at zero leading power factor and 34,000 kVAr at zero lagging power factor.



1 110-kV switchgear
2 25-kV switchgear
3 6-kV switchgear
4 6-kV unit service system I
5 6-kV unit service system II
6 6-kV unit service system III*A*
7 6-kV unit service system III*B*
8 6-kV station-service system
9 440-V main distribution – Unit I
10 440-V main distribution – Unit II
11 440-V main distribution – Unit III
12 440-V main distribution – Station-service system
13 220-V lighting distribution
14 440-V distribution, Turbine – Unit I
15 440-V distribution, Boiler – Unit I
16 440-V distribution, Turbine – Unit II
17 440-V distribution, Boiler – Unit II
18 440-V distribution, Boiler – Unit III*A*
19 440-V distribution, Turbine – Unit III
20 440-V distribution, Boiler – Unit III*B*
21 440-V distribution, Turbine house
22 440-V distribution, Water treatment
23 440-V distribution, Oil preheater house
24 440-V distribution *a*, Intake structure
25 440-V distribution *b*, Intake structure
26 440-V distribution, Coal handling plant
27 440-V distribution, Oil pump house
28 125-V d.c. distribution
29 Synchronous-condenser motor-generator, Unit I
30 Synchronous-condenser motor-generator, Unit II

Generation and distribution
Unit-service system
Station-service system

Fig. 6 Basic electrical layout diagram of the Badalona power station

Electrical equipment

The generator transformers are regulatingt hree-winding transformers rated

42.5 MVA at 100/25.6 kV
42.5 MVA at 100/6.4 kV or 11.1 kV
42.5 MVA at 25.6/6.4 kV or 11.1 kV

Each transformer is designed for natural and air-blast cooling. With natural cooling all three windings can be simultaneously loaded with 25,000 kVA. The high voltage can be regulated by means of an on-load tap changer arranged in the neutral leads. For voltage regulation on the 25-kV side, a regulating autotransformer with a circuit rating of 42.5 MVA is allocated to each three-winding transformer. Regulation is effected by buck and boost connection of the series winding. With natural cooling the circuit rating is 32,000 kVA. The power generated is supplied through the switching stations of the power plant to three networks of various voltage ratings.

The 110-kV outdoor switching station supplies via two overhead transmission lines the nearby Casa Barba substation and thus the 110-kV grid of the province of Catalonia. A third overhead transmission line supplies via a transformer an older 25-kV substation which is located directly adjacent to the power plant. Fig. 7 shows a part of the 110-kV outdoor switching station with its two busbar systems, one service bus and one auxiliary bus.

In the final stage of construction the 25-kV outdoor switching station has 21 outgoing feeders. The existing feeder lines, designed partly as underground cables and partly as overhead transmission lines, feed into the Barcelona municipal distribution system. This substation has three bus systems. The 110-kV and the 25-kV systems are operated with an earthed neutral.

The 6-kV system switching station is of the indoor type in open design with two busbar systems. It is arranged on three floors of the 6-kV switching house and has

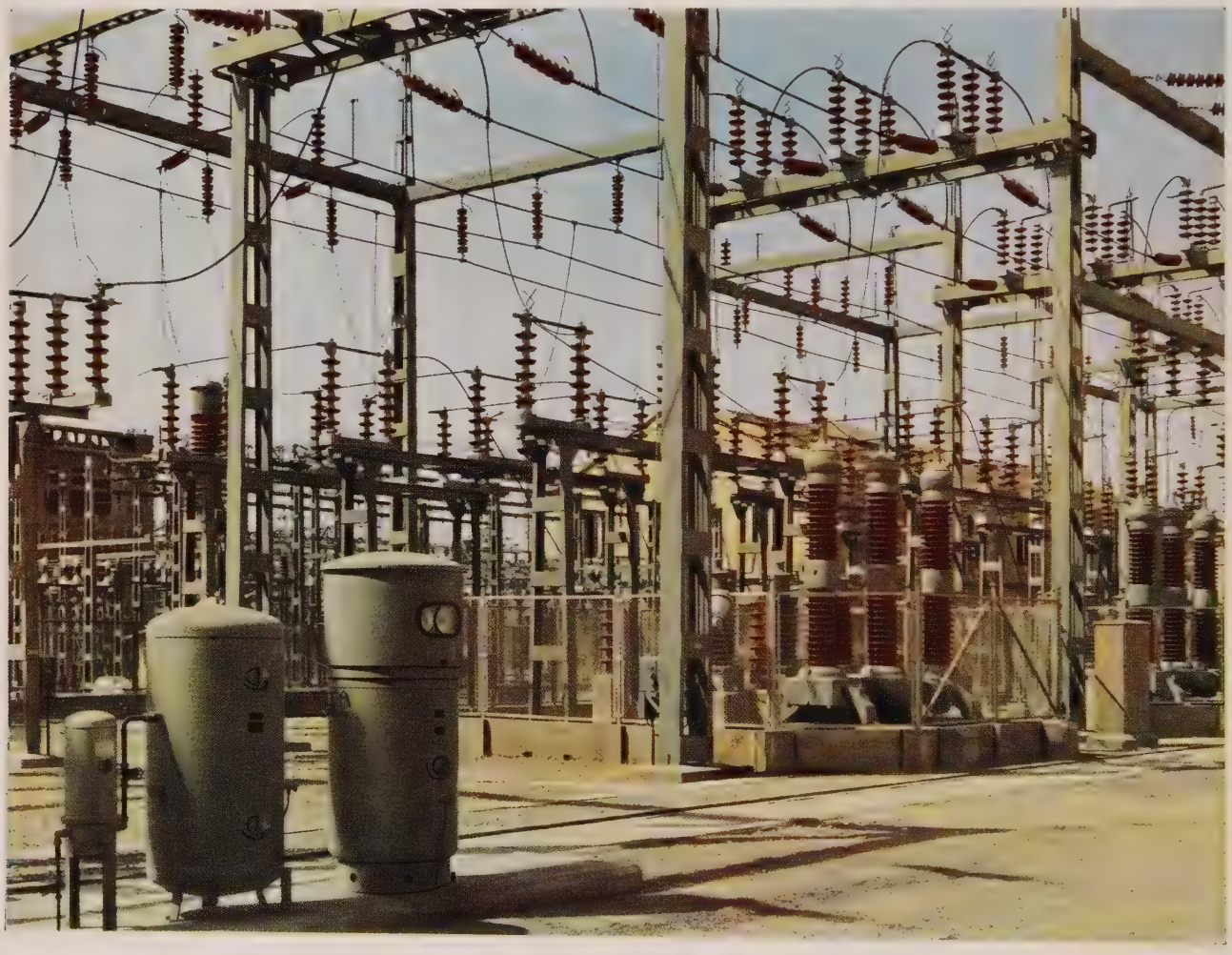


Fig. 7 View of the 110-kV outdoor switching station

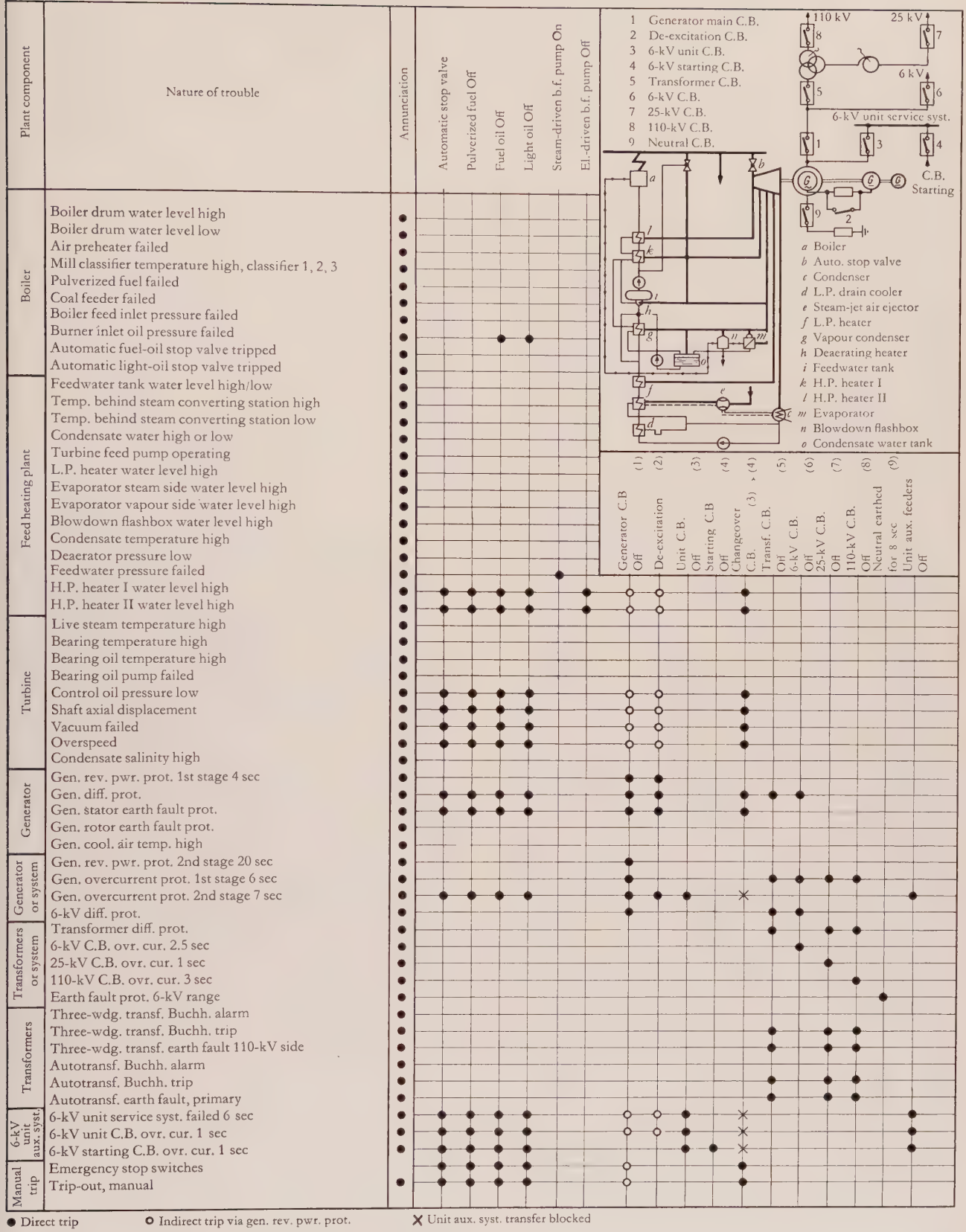


Table 1 Supervisory and protective devices of a 34-MW unit

31 cable feeders for the supply of the load centres in the immediate vicinity. Two further feeders power the 6-kV starting bus. The individual feeders are single, double and triple cable feeders so that only one circuit breaker is provided for each of the double and triple cable feeders. A spare circuit breaker is provided in common for all feeder circuits; it can be connected on to the outgoing cables via the auxiliary busbars and the auxiliary bus selectors.

The station-service switchgear and transformers are installed in the centrally located control room and station-service building at elevation +4.80 m. This arrangement provides the shortest connections between the control room and switchgear and also between the switchgear and loads. While the 6-kV switchgear is of the sheet-steel enclosed unit type, the 440-V main distribution boards are of the steel-framed open type. The subdistribution boards near the low-voltage auxiliaries are iron-clad. All station-service switchgear and distribution boards are of the single bus type.

Essential feeder control circuits and all tripping circuits of the protective equipment and all indicating systems operate on 125 V d.c. The d.c. circuits are supplied from a d.c. distribution board located in the electrical control room. This distribution board also feeds several essential motor drives and all emergency lighting circuits.

In addition to the control stations for the turbines and feed heating plants, the oil pumping station, oil-preheating station, coal handling plant and the closed service water circuit, there are two control rooms arranged adjacent to each other, namely, the thermal and the electrical control rooms; these are located on the main operating floor at elevation +13.80 m in the central control room and station-service building.

The thermal control room houses the equipment for the control, regulation and supervision of the boiler plant. Each boiler is equipped with an electrical automatic controller which adjusts the fuel (coal or oil), air and feedwater supply to the boiler in accordance with the boiler load and maintains the live steam temperature and pressure constant.

The electrical control room controls and supervises the generators, transformers, station-service switchgear and the 110-kV, 25-kV and 6-kV switching stations associated with the power plant.

The power station is provided throughout with extensive mechanical and electrical supervisory and protective equipment. Table 1 gives a survey of the principal supervisory and protective equipment of a 34-MW unit system and of the safety measures which are initiated by the protective equipment.

Tripping of the individual supervisory and protective devices is indicated audibly and visually in the control rooms and/or on the relevant control and supervisory panels.

The power station is cabled throughout with thermoplastic (Protodur*) cables. A total of 155 km (84 miles) of cables has been installed.

Furthermore, the first and second stage of construction includes 360 motors with a total installed capacity of about 12,900 kW.

Shipping and erection

As a result of thorough investigations it was found that the transport by sea was the most economical method of getting the material to the site. More than 12,000 tons of material were transported by ship from Germany to Barcelona and from there by road to the nearby construction site.

Initial difficulties encountered in compacting the subsoil led to unavoidable delays. In spite of these set-backs the first two turbo-sets had to be completed as speedily as possible owing to the fact that the dry period which set in during the construction of the first stage resulted in a considerable shortage of electrical power. The erection work was therefore under pressure right from the beginning owing to the extremely short time available for erection. By increasing the number of erection personnel and the daily hours worked and by the considerable efforts of all participating in this work it was possible to complete the first two generating sets so that they could be put into commercial operation during the most adverse period between December and January 1957/58. The commissioning of the first two turbo-sets which was honoured by the presence of the Caudillo was a very important event for the province of Catalonia.

The total construction period for the first and second stage of construction lasted 30 months. This could be achieved only as a result of the generous and energetic assistance given by the customer, the Fuerzas Eléctricas de Cataluña S.A. and by the well-timed intermeshing of civil engineering and erection work.

The Badalona steam power station is one of the most modern and largest thermal power stations in Spain. It makes an important contribution to the power supply of Catalonia.

As a result of the good operational experience and the reserve capacities incorporated in the mechanical and electrical equipment it has been possible to increase the output of the 34-MW units to 35.5 MW and the output of the 69-MW turboset to 72 MW, thus raising the installed capacity of the Badalona steam power station in the first two stages of construction to a total of 143 MW.

* Trade-mark

Coaxial Cable for Argentina

By Rudolf Zöckler † and Werner Schubert

Electrical characteristics

The coaxial cable is used for the simultaneous transmission of multi-channel telephone signals and television programs, radio programs and tv sound, as well as district and short-haul telephone conversations; it also serves for the remote powering of unattended repeater stations over coaxial pairs. It is therefore evident that the cable has to meet very exacting technical requirements. Close investigations had for this reason to be carried out on the first installed cable sections and on trial routes in order to obtain an idea of the mutual interference that is liable to occur between individual line circuits within the cable. The measurements performed on the trial routes yielded satisfactory results and confirmed the data calculated at the development stage. Such basic investigations, continuous quality control during production, and a final overall electrical test performed on each length of cable before leaving the factory were essential in achieving the values guaranteed for the completed cable route. The success of these efforts is indicated most clearly in the results of the acceptance tests performed on both the factory lengths of cable and on the installed sections of the route.

In testing the coaxial pairs at the factory, special attention had to be paid to characteristic impedance and its variations from one length of cable to another and its uniformity from one length to another. The average characteristic impedance of the first 260 lengths was 75.15 ohms, which was reduced in the course of time to 75.08 ohms. In our present production the characteristic impedances range between 74.9 and 75.23 ohms (the CCITT accepts 74 and 76 ohms as limits). An index of the general quality attained is represented by the average square deviation of the values measured for individual lengths from the average route value for each coaxial pair, which is only 0.09%.

In the interest of minimum unbalance and line attenuation, the nominal mutual capacitance of the carrier star quads in the core of the cable was set at 31 nf/km (approx. 49.8 nf/mi.). The high uniformity achieved in production may be seen from the small deviation of the average mutual capacitance of −2.4 to +3.9% from the nominal value (Fig. 1), which permitted the expectation that the input impedance characteristic of the carrier side circuits would exhibit only minor deviations as a function of frequency. The low level of unbalance and the satisfactory relation between capacitive unbalance and inductive unbalance made it unnecessary to institute any of the grouping measures conventionally used in the region of the carrier repeaters between the carrier circuits in order to maximize near-end crosstalk attenuation.

The space available in the outer interstices of the coaxial pairs allowed a reduction of the average mutual capacitance of 45 nf/km (aprox. 72.3 nf/mi.) specified by the customer for the v-f star quads to 36 nf/km (approx. 57.8 nf/mi.) and that of the shielded radio program pairs to a nominal value of 37 nf/km (approx. 59.4 nf/mi.). In addition to reducing the line attenuation slightly, this measure also lowered the level of unbalance. Although the customer conceded a spread of ± 12% from the nominal value of the mutual capacitance, this was utilized in the case of the v-f star quads only from −9 to +3.4% and for the r-f pairs only from −8 to +1.1%. Grouping designed to minimize mutual capacitance variations along the route sections were thus likewise unnecessary also with these types of circuit.

In addition to the conductor or loop resistance, resistance difference and insulation resistance measured for each length of cable as a matter of routine, there are also other characteristics that furnish information on the relations existing between the various types of circuit. Special mention should here be made of the investigation of the crosstalk between the carrier side circuits and the r-f pairs, as well as between the r-f pairs and the v-f star quads, by measuring the magnetic unbalances. The objective was in all cases attained without difficulty.

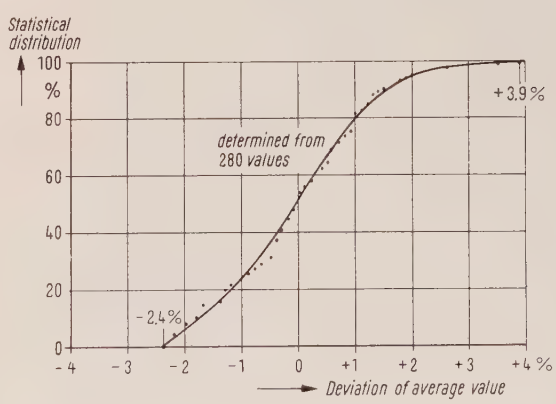


Fig. 1 Percentual deviation of average mutual capacitance of carrier quads from nominal value (± 5% admissible)

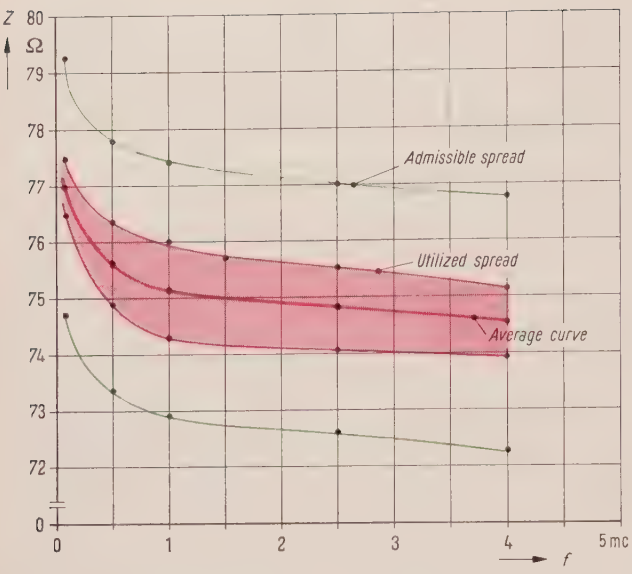


Fig. 2 Spread of input impedance of coaxial pairs

Mechanical characteristics

Production was planned in such a way that the greater part of the cable could be supplied in lengths of 458.5 m (1504 ft), inclusive of the allowance for splicing. Four lengths thus come to 1830 m (6004 ft), which is equivalent to a v-f loading coil section. The makeup of the cable allows bending radii of down to 0.8 m (2.6 ft), which was frequently of great advantage in laying and installation. As a result of the gas pressure alarm system, the cable is exposed to an overpressure which ranges between the operating point of the contact pressure gage (approx. 0.6 kp/cm² or 8.5 lbs/sq. in.) and the initial operating pressure of approx. 1 kp/cm² or 14.2 lbs/sq.in.). The customer therefore specified that the coaxial cable should have a lead sheath with a minimum thickness of 2.1 mm (0.083 in.).

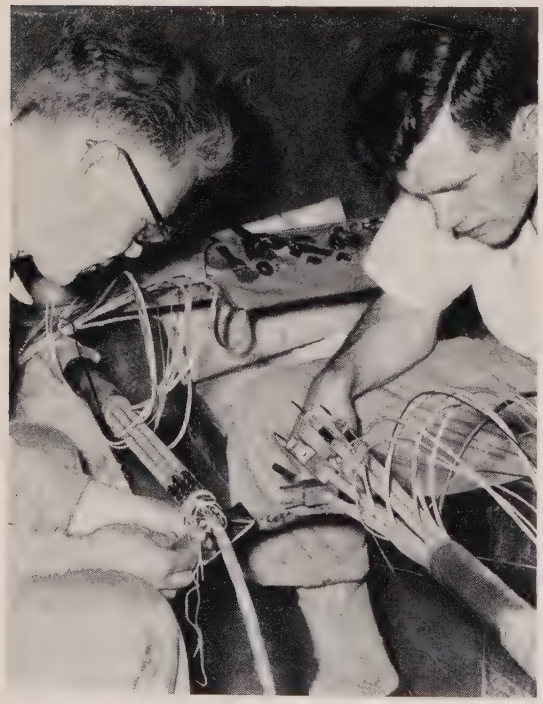


Fig. 3 Careful splicing of coaxial pairs is necessary to avoid reflections at these points

The cable system is protected by the gas-pressure alarm system. Leaks in the cable sheath cannot be coarsely localized with the aid of the contact pressure gages until they are sufficient to secure that the difference in pressure between two contact pressure gages is greater than the operating tolerance resulting from production capabilities. The minimum leakage to which the contact pressure gages of the coarse localization system will still respond is, assuming an initial operating pressure of 1 kp/cm² (14.2 lbs/sq.in.), about 20 ltr/hr (0.71 cu. ft/hr). For a moderate outlay, leakages below this figure down to about 10 ltr/hr (0.35 cu. ft/hr) can be localized with precision pressure gages. Such outlay is, however, worth while only during the installation of the system, when it can be used to insure that the cable system is as "tight" as possible. For ordinary operation it is entirely sufficient to restrict fault localization to leakages that cause positive operation of contact pressure gages, for, in the case of minor damage, the cable will remain protected against the ingress of moisture over a lengthy period by the overpressure (protective pressure) at the leak. The localization and elimination of these minor leakages can usually be deferred until a suitable occasion presents itself. The gas volume of about 10,000 ltr (353 cu. ft) in a 9-km ($5\,^5/_8$-mile) coaxial repeater span with an operating pressure of 1 kp/cm² (14.2 lbs/sq.in.) is so great that, even in the case of relatively serious leaks of, say, 300 ltr/hr (10.6 cu. ft/hr), sufficient gas remains to protect the cable from the ingress of moisture for an adequate length of time until it is convenient for remedial measures to be taken.

Results of acceptance tests

The table on page 47 shows the principal guaranteed values, which are based on CCITT recommendations and VDE* specifications. In many cases it was found possible to achieve considerably better values than those specified by the customer.

In the case of the coaxial pairs the input impedance curves deviated from the smoothed average curve by only ±1.2% (Fig. 2). This satisfactory achievement may be ascribed to the high uniformity of the finished product and also to careful splicing (Fig. 3) of the coaxial pairs at the cable joints. The line attenuation measured thus far conforms to the guaranteed values. Crosstalk between coaxial pairs is determined largely by the constructional design of the outer conductor and the chosen shielding materials. The quality of the product and the type and

* Assn. of German Electrical Engineers

Characteristic	Measuring frequency	Guaranteed value
A. Repeater span of coaxial pairs 2.6/9.5 mm (0.104/0.375 in.), l = 9 km (5 5/8 mi.), cable temperature t_0 = 10 °C		
Characteristic impedance Z	2.5 mc	74 to 76 ohms
Uniformity of characteristic impedance as deviation from respective average curve $\Delta Z/Z$	60 kc to 10 mc	$\leqq \pm 3$ %
Line attenuation α	2.5 mc	$\leqq$ 0.44 nepers/km ($\leqq$ 6.15 db/mi.)
	4 mc	$\leqq$ 0.55 nepers/km ($\leqq$ 7.69 db/mi.)
	6 mc	$\leqq$ 0.68 nepers/km ($\leqq$ 9.51 db/mi.)
Near-end crosstalk a_n	60 kc	$\geqq$ 10.1 nepers ($\geqq$ 87.7 db)
	4 mc	$\geqq$ 14.7 nepers ($\geqq$ 127.7 db)
Far-end crosstalk $a_f - a$	60 kc to 6 mc	$\geqq$ 9.8 nepers ($\geqq$ 85.1 db)
B. Repeater span of 0.9 mm (approx. 20 lbs/mi.) carrier star quads, l = 18 km (11 1/4 mi.), cable temperature t_0 = 10 °C		
Uniformity of characteristic impedance as deviation from an average curve $\Delta Z/Z$	12 to 108 kc	$\leqq \pm 7$ %
or as return loss a_F	12 to 108 kc	$\geqq$ 3.3 nepers ($\geqq$ 28.7 db)
Line attenuation α	108 kc	$\leqq$ 0.36 nepers/km ($\leqq$ 5.04 db/mi.)
Near-end crosstalk a_n 100% of values	108 kc	$\geqq$ 6.5 nepers ($\geqq$ 56.5 db)
90% of values	108 kc	$\geqq$ 7.0 nepers ($\geqq$ 60.8 db)
Far-end crosstalk $a_f - a$ 100% of values	108 kc	$\geqq$ 8.2 nepers ($\geqq$ 71.2 db)
90% of values	108 kc	$\geqq$ 8.5 nepers ($\geqq$ 73.8 db)
C. Repeater span of 0.9 mm (approx. 20 lbs/mi.) r-f pairs, l = 45 km (28 1/8 mi.), cable temperature t_0 = 10 °C		
Uniformity of characteristic impedance as deviation from an average curve $\Delta Z/Z$	up to 15 kc	$\leqq \pm 10$ %
or as return loss a_F	up to 15 kc	$\geqq$ 3 nepers ($\geqq$ 26.1 db)
Line attenuation α	0.8 kc	$\leqq$ 0.058 nepers/km ($\leqq$ 0.811 db/mi.)
	3 kc	$\leqq$ 0.066 nepers/km ($\leqq$ 0.922 db/mi.)
	10 kc	$\leqq$ 0.069 nepers/km ($\leqq$ 0.964 db/mi.)
	15 kc	$\leqq$ 0.075 nepers/km ($\leqq$ 1.05 db/mi.)
Near-end crosstalk a_n	4.5 kc	$\geqq$ 13 nepers ($\geqq$ 112.9 db)
Far-end crosstalk $a_f - a$	4.5 kc	$\geqq$ 9.5 nepers ($\geqq$ 82.5 db)
D. Repeater span of 0.9 mm (approx. 20 lbs/mi.) v-f star quads, l = 72 km (45 mi.), cable temperature t_0 = 10 °C		
Uniformity of characteristic impedance as deviation from an average curve $\Delta Z/Z$	0.3 to 3.4 kc	$\leqq \pm 10$ %
or as return loss a_F	0.3 to 3.4 kc	$\geqq$ 3 nepers ($\geqq$ 26.1 db)
Line attenuation α	0.8 kc	$\leqq$ 0.029 nepers/km ($\leqq$ 0.405 db/mi.)
	3.4 kc	$\leqq$ 0.031 nepers/km ($\leqq$ 0.432 db/mi.)
Near-end crosstalk a_n	1 kc	$\geqq$ 7.0 nepers ($\geqq$ 60.8 db)

Survey of guaranteed values

quality of installation do not themselves exercise any notable influence on crosstalk. The shielding materials and the interstice elements, on the other hand, are a factor, especially at frequencies at the low end of the spectrum. The crosstalk attenuation between coaxial pairs rises in a practically linear fashion with frequency and is lowest at 60 kc, which is the bottommost transmitting frequency of the V 960 system. It is here usually sufficient for the acceptance tests to show that the guaranteed value is obtained at this frequency on several 9-km (5 5/8-mile) route sections. At 4 and 6 mc the outer conductors already shield so effectively that crosstalk attenuation exceeds the measuring limit of 16 nepers (139 db).

Compared with the $\geqq$ 9.8 nepers ($\geqq$ 85 db) guaranteed as a basic value for far-end crosstalk for all combinations, the measurements showed a safety margin of at least 1.35 nepers (11.7 db). In practice this safety margin is considerably greater, because the two V 960 systems for incoming and outgoing telephone circuits are individually connected to adjacent coaxial pairs, whose far-end crosstalk attenuation is approx. 1.8 nepers (15.6 db) higher than that of nonadjacent pairs. The balanced carrier side circuits also contribute to crosstalk on the coaxial pairs. No guaranteed values were here agreed upon with the customer, but appropriate guiding values were computed from the general data contained in the

Fig. 4 Installation of balancing capacitors for equalizing excessive far-end crosstalk unbalances

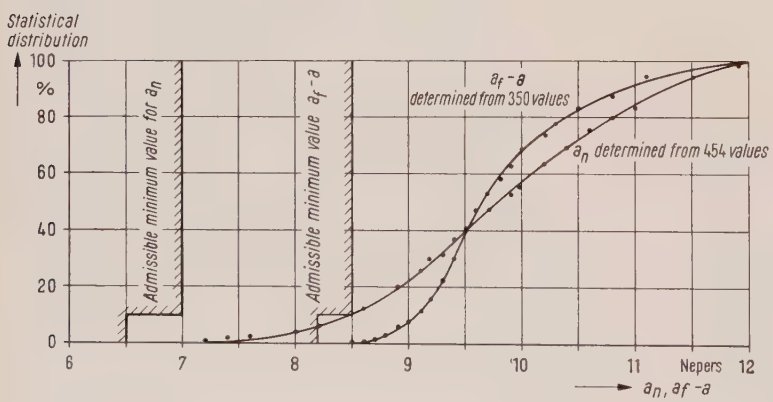


Fig. 5 Near-end and far-end crosstalk attenuation between carrier circuits; measured at 108 kc on 11 $^1/_4$-mile repeater spans

specifications covering admissible crosstalk. According to these the near-end crosstalk attenuation in the region where the two carrier systems V 960 and Z 12 overlap (60 to 108 kc) must on no account fall below 11.4 nepers (99 db). The far-end crosstalk attenuation should here be $>$ 11.5 nepers ($>$ 99.9 db). As compared with these guiding values, measurements performed in the field disclosed minimum values of 11.9 nepers (103.4 db) for near-end crosstalk and 13.5 nepers (117.5 db) for far-end crosstalk.

The maximum deviation of the characteristic impedance of the 12 channel carrier pairs from the average curve calculated from the measurements for all line pairs in the band from 12 to 108 kc ranges within ±6%, which is considerably better than the guaranteed value. The average value of the line attenuation of the carrier star quads measured at 108 kc was calculated to be 0.33 nepers/km (2.87 db). Compared with the guaranteed value of $<$ 0.36 nepers/km ($<$3.13 db), there is thus a margin of roughly 7.5% which benefits the transmission performance of the Z 12 circuits.

Although no attention was paid to the near-end crosstalk attenuation between the carrier lines during the installation of the cable, all the measuring results meet the guaranteed values for near-end crosstalk, with a safety margin of 0.7 nepers (6 db) in the case of the poorest instance. Far-end crosstalk was balanced in a two-point arrangement by inserting balancing capacitors (Fig. 4), whereas the active components of the complex residual unbalances to be balanced were previously minimized through the cross-connection of pairs at three points of each repeater span. Analysis of the measuring results shows that the guaranteed value of 8.2 nepers (71.2 db) at 108 kc is achieved with 8.5 nepers (73.8 db) in all cases (Fig. 5).

The line attenuation and characteristic impedance of the shielded radio program pairs satisfy the conditions of guarantee with satisfactory certainty. As with the carrier side circuits, the deviation of the individual characteristic impedances from an average curve was checked by comparison with a balancing network.

The guaranteed value was satisfactorily maintained over the entire frequency range up to 15 kc, with a maximum deviation of 9%. Whereas in the case of carrier circuits the signals are transmitted in either direction in separate frequency bands, so that a limitation of near-end crosstalk attenuation is necessary only on account of reflections at the ends of the repeater span, in the case of the shielded r-f pairs the same frequency band has to be used for both directions of transmission. The guarantee with respect to near-end crosstalk at the reference frequency 4.5 kc thus provided for a basic attenuation of at least 10.1 nepers (87.7 db). In a 45-km (28 $^1/_8$-mile) radio program repeater span this means that measurements must show a minimum of 13 nepers (113 db) for near-end crosstalk attenuation in addition to the line attenuation of 2.9 nepers (25.2 db) appropriate to this length of span. In contrast with this, the values measured during the acceptance tests were found to be above the measuring limit of the measuring setup used, which was 14.5 nepers (126.3 db). Thus no danger of mutual interference between programs exists.

The potential crosstalk in the range from 6 to 15 kc between the carrier side circuits and the r-f pairs, and also the mutual interference between v-f circuits and r-f pairs, were also investigated during the acceptance tests. In no case were the guiding values for admissible crosstalk calculated from the general data given in the specifications exceeded.

The results of the acceptance tests performed on the v-f circuits met the given requirements.

The tests agreed upon with the customer in connection with the gas-pressure alarm system furnished entirely positive results.

The results of the acceptance measurements show that the guaranteed values are achieved satisfactorily and, in most cases, with a high degree of certainty. The first transmission results confirm the high quality of the communications circuits. Even if the cable system were later to be extended to a length of over 2500 km (1562 $^1/_2$ miles) (CCITT Reference Circuit), no deterioration in quality due to crosstalk and distortion is to be expected in view of the liberal margin left by the crosstalk attenuations of all circuits. The gas-pressure alarm system will contribute decisively to the protection of the valuable cable system.

Transmission Technique in Argentina's Long-Line Communications Network

By Ludwig Graf and Gustav Hohl

With a view to the future Pan American communications network, the Argentinian PTT has specified the most exacting requirements for all the equipment of its new communications network. These requirements largely conform with CCITT and CCIR recommendations.

As the quality of transmission of Siemens carrier systems exceeds in many respects that called for by the CCITT, there was no problem in satisfying the Argentinian specifications. The overall transmission equivalent tolerances of Siemens telephone systems are, for example, narrower; also the requirements with respect to the admissible noise power are met with a considerable margin to spare.

Telephone and telegraph circuits

Fig. 1 shows the new telephone network. The thickness of the lines in the diagram gives an approximate idea of the size of the groups of voice circuits. The breadth of the outer frame around the coaxial route represents a capacity of almost 2000 voice circuits, which includes full utilization of the standby coaxial lines. The coaxial cable network (red lines) embodies the following telephone facilities:

Large groups of telephone circuits for the main routes of the network: the maximum numbers of telephone circuits range at present between 600 for the Buenos Aires – Rosario and Buenos Aires – Mar del Plata routes, and 240 or 300 for the Buenos Aires – Chivilcoy, Rosario – Santa Fé and Rosario – Cañada de Gómez routes. Individual supergroups (60 channels) are here dropped at major towns along the routes and in some cases extended further. The coaxial cable pairs are equipped with the V 960 telephone system, which provides 960 voice circuits on two coaxial pairs.

Medium-size groups of telephone circuits for intercommunication between medium-size towns: groups of between 12 and 36 voice circuits are at present planned and, with the Z 12 12-channel system, will be accessible on the star quads in the interstices of the coaxial cable.

Small groups of telephone circuits for intercommunication between small towns: these are run in the loaded telephone lines in the interstices of the coaxial cable.

On the open-wire line routes (green lines) – up to 625 miles in length and presently equipped with groups of

about 200 telephone circuits – 12-channel carrier systems are used and serve primarily for long-distance traffic between large cities; 3-channel carrier systems are used for radio program transmission and for telephone communication between medium-size towns. The telephone channels of the open-wire lines serve for short-haul traffic and some are dropped at each town through which the open-wire line network runs. Here again the thickness of the lines in Fig. 1 indicates the size of the group of voice circuits, but on a five times greater scale than in the case of the coaxial network.

Up to 24 teleprinter channels can be accommodated in the frequency band of a single telephone channel (300 to 3400 cps). WTS 24 systems are used in Argentina for this purpose. These are 24-channel v-f carrier telegraph systems that operate with amplitude modulation on the neutral current principle. Each line in Fig. 2 indicates a telephone channel so used; it thus represents a group of 24 telegraph channels.

Some of the telegraph channels are to be allocated to the postal telegram service. In this connection it should be noted that the Argentine telegram service is run in complete independence of the telephone service. Mail

Fig. 1 Telephone network

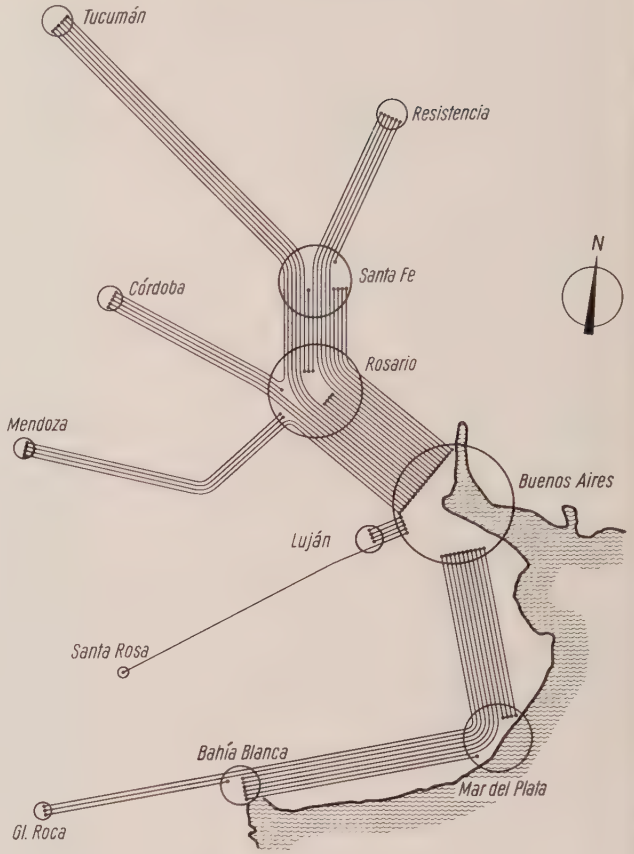


Fig. 2 Telegraph network

service and telegram service are under the control of the «Dirección Nacional de Comunicaciones», while local and long-distance telephone service and telex service are the responsibility of the ENTel (Empresa Nacional de Telecomunicaciones).

A large quantity of the telegraph channels operating on the principle described are also to be allocated to the large telex network with long-distance dialing facilities, the equipment for which was also supplied by the Siemens organization.

Radio and tv program distribution

Fig. 3 shows the tv transmission network. Two coaxial pairs – one for each direction – equipped with 6-mc repeaters are provided for the transmission of tv programs. Tv sound is transmitted in a bandwidth of 30 to 15,000 cps over two or three high-grade shielded v-f radio program pairs in the interstices of the coaxial cable.

As the spacing between the intermediate repeaters for tv and for multi-channel telephony is the same ($5\,^{5}/_{8}$ miles), the same repeater stations can be used. The use of the coaxial network for both tv and multi-channel telephony is therefore of great economic saving. The same remote powering and remote control equipment is also used for both systems.

All transmitting stations within the country can be linked by way of the two-way tv transmission lines to form a network. As in Germany, programs of sporting events, etc., are fed into the overall network from its terminals and from branch-off points such as Mar del Plata and Rosario by way of the Buenos Aires switching center. Rapid switching from one program pickup point to another is in this way possible.

The cost of staging programs of equivalent value in separate studios in the various cities would come considerably higher than those of picture transmission. For local programs simpler studios are sufficient.

Radio programs are not transmitted over the v-f radio program lines of the coaxial cable but by carrier in a band of three combined telephone channels in the basic group of the multi-channel system. From Buenos Aires four separate programs can be transmitted throughout the entire country (Fig. 4). From the terminals of the coaxial cable the radio programs are transmitted by carrier over Z3F open-wire line systems to, for instance, Tucumán, Posadas, Mendoza and Bahía Blanca. Whereas one of the four channels serves for two-way operation, the three others are operated in one direction only, with Buenos Aires acting as a junction center.

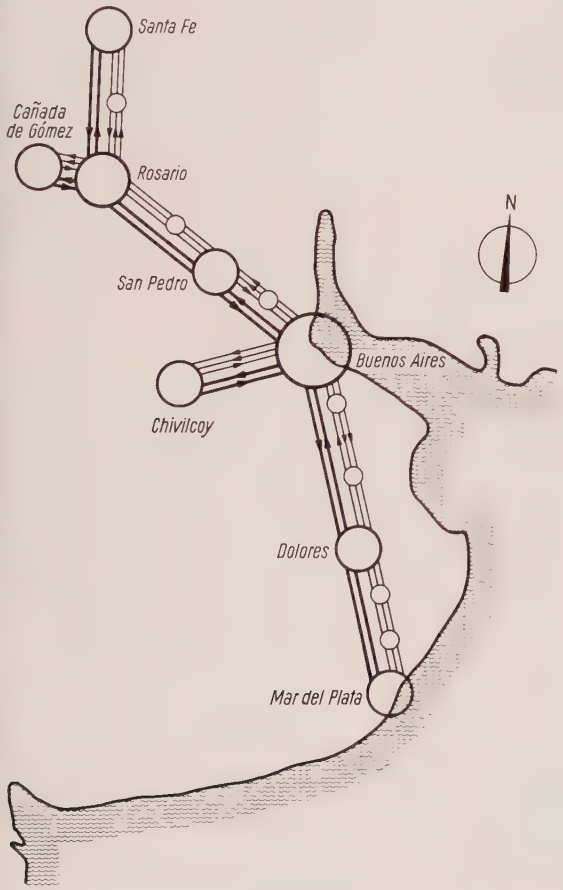


Fig. 3 Television transmission network

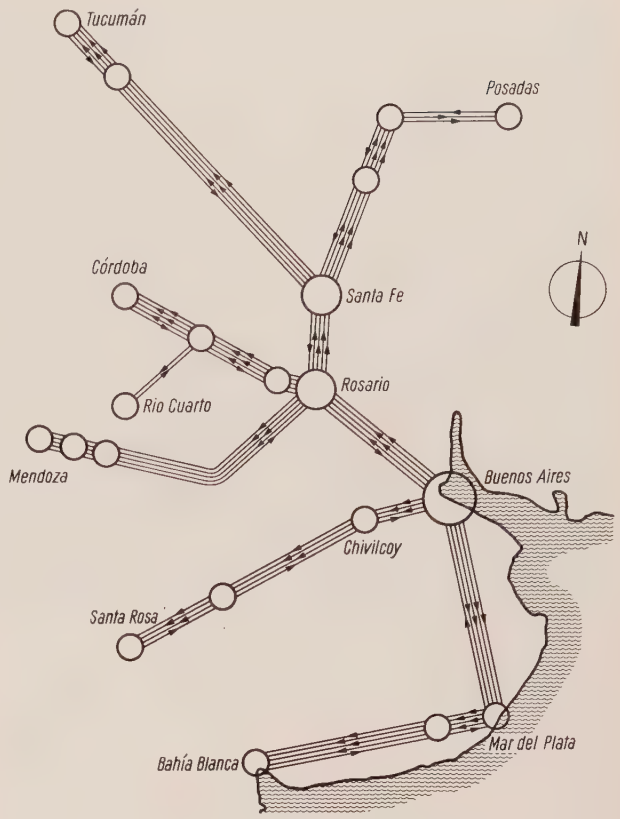


Fig. 4 Radio program network

Carrier telephone systems

The frequency allocations of the carrier systems are all essentially matched, so permitting the uniform application of the different modulation stages in the various systems and, above all, the carrier switching and drop-out of 12-channel and 60-channel groups without translation into the v-f position. In Argentina the given possibility of economizing in modulation equipment is very frequently made use of at points where the coaxial system and open-wire line systems meet.

The channel modulators used in all carrier systems provide a separate dialing and signaling channel (3850 cps) for each voice channel. The use of the tubes of the channel receiving amplifier is here shared by the signal receiving circuit. The 3850-cps dialing and signaling system is immune to interference from speech transmission and conversely permits the transmission of meter and control pulses during the call. This is of particular value in nationwide dialing.

Apart from the C3g tube in the line amplifier of the V 960 coaxial system and in the tv amplifier, and the F2a tube in the power stages of the line amplifiers of the open-wire line systems, the carrier systems all make exclusive use of the C3m pentode. This restriction of the number of tube types and the use of identical subassem-

blies in all systems is of great importance in that it simplifies maintenance work on the equipment and keeps down stockkeeping expenditure. This is of particular advantage in the case of the extensive Argentinian network, for it would come extremely expensive to have to maintain a stock of a large number of tube types and spare parts at the many repeater stations.

High service reliability – a vital factor in such a large network – is secured for the carrier systems among other things by duplicating important units of equipment with standby equipment with changeover facilities which are automatically triggered in the event of trouble. High-speed switching devices control changeover operations. The line amplifiers of the coaxial systems operate with parallel-connected tubes. Short interruptions of the telephone service and of the telegraph service, which is particularly susceptible to transmission breakdowns, are in this way precluded.

In Argentina the simple expansion of existing equipment must be readily possible because, for instance, the V 960 coaxial system is not yet utilized to capacity although plans for future expansion have already been drawn up. As the carrier equipment is designed on the unit construction principle, new offices and stations need only be equipped for their first stage of development.

Open-wire line routes

Communications links with the sparsely populated interior of the country and interconnecting the large towns there, which are located relatively far apart, run as hitherto over open-wire lines (Fig. 5). As telephone traffic to large towns such as Córdoba and Mendoza is extremely heavy, the open-wire lines of these routes have to be operated with carrier equipment. Given four cross-arms with four pairs each, $4 \times 4 \times 16 = 256$ voice circuits per pole are possible. Each pair is operated with a 3-channel and a 12-channel carrier system, so yielding 16 voice circuits (including the telephone circuits) per line. In the case of pole systems that have to carry a great many open-wire lines, very stringent demands exist with respect to constructional tolerances. Long years of experience in this field have placed the Argentinian administration in a position to take care of the construction and transposition of these high-grade open-wire lines by itself. For parallel operation using the same pole system, the carrier systems must, however, not have any all too exacting requirements with respect to the mutual decoupling of parallel lines. As a result of their constructional design and different frequency allocations (transmission in regular or inverted position, frequency-shifting of top band, frequency frogging at repeater stations), Siemens carrier systems permit the suppression of intelligible crosstalk to a very large extent. As the principal source of crosstalk may be the entrances of the open-wire lines at the repeater stations, these should be given due attention.

No hoar frost is encountered in the area in which the open-wire line carrier systems are installed. Thus the gain reserves provided in the amplifiers to overcome the effects of hoar frost may be used to establish longer repeater spans in cases where, for instance, the operation of intermediate repeaters in sparsely populated areas would come too expensive.

The following open-wire line carrier equipment is used:

	Terminals	Relay stations
Z12F System	184	125
Z3F System	170	31

Fig. 5 Open-wire line telephone pole system outside Rosario

Coxial routes

The coaxial routes form the backbone of Argentina's long-line communications network. The cable with its six coaxial pairs is expected to be able to satisfy all demands for communications channels along these routes. Of the six pairs, two are set aside for 960 telephone circuits and two for the transmission of tv programs in both directions; the fifth and sixth are held in reserve for a further 960 telephone circuits. Beyond this the quantity of telephone circuits could be more than trebled by using the V 2700 carrier system (12-mc bandwidth) and halving the present repeater spans.

An increased demand for telephone circuits is to be expected, for instance,

following the introduction of direct distance dialing, which calls for the continuous availability of free channels and, as no delays are encountered in direct distance dialing, encourages subscribers to use their telephones more.

The V 960 multi-channel system meets all CCITT recommendations. The technical requirements this involves are evidenced, among other things, by the narrow tolerances of the carrier generators. The frequencies of the carriers required for translation purposes must here be stabilized to within $\pm 1 \times 10^{-7}$.

The repeater stations of the V 960 carrier telephone system and the carrier television system (spaced approx. $5^5/_8$ miles apart) are usually unattended and remote powered. Attended and power-feeding intermediate repeater stations are required only every $43^3/_4$ to $62^1/_2$ miles. In Argentina towns in which a power current network is available will always be found within this distance.

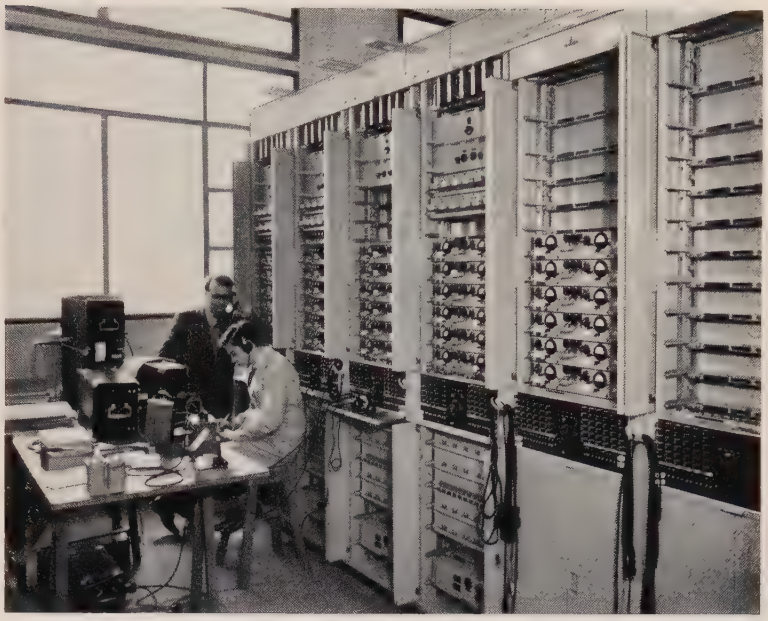


Fig. 6 Layout of v-f carrier telegraph cabinets in Rosario station

As the majority of repeater stations along the coaxial route remain unattended, relatively few personnel are required. Thus highly skilled personnel are assigned to duty only at a small number of central control points, where the state of operation of equipment at unattended stations is indicated by means of a remote control system.

The service personnel responsible for checking unattended repeater stations at regular intervals have at their disposal a separate service channel that is operated over two phantom circuits of the carrier quads and dropped at each unattended repeater station along the route. Service calls between main and sub-centers or control and level indication information sent in connection with radio and tv transmission, etc., are carried by normal telephone channels.

The remote power supply is threephase 750 v, 50 cps and uses the inner conductors of the six coaxial pairs. These inner conductors are connected in parallel two at a time. The threephase current is converted at the remote-powered repeater stations into single-phase a-c with the aid of a Scott system, so securing the even loading of the lines.

The remote power supply is so dimensioned that it is also able to power the v-f radio program amplifiers and the Z 12 intermediate repeaters. An allowance has been made for the additional load when the reserve coaxial lines and all seven star quads (14 Z12 systems as compared with from one to three today) are placed in use.

The particular problems of tv transmission over coaxial cables reside in the fact that, in the transmission range from 1 to 6 mc, not only amplitude distortion but also the delay distortion has to be equalized. In the case of picture transmission such distortion would make itself felt in the form of extremely disturbing picture distortions; the human ear on the other hand is relatively insensitive to the effect of delay distortion. The Argentinian tv transmission system operates with a cable network almost 750 miles in length. The delay is therefore equalized by echo equalizers to such an extent that, even when the route is extended beyond 1500 miles, the value specified by the CCITT will not be exceeded.

The particular advantages of carrier radio program transmission are that no separate radio program pairs are any longer required in the cable. It will thus readily be possible in the future to make further radio program channels available on all routes without new lines having to be laid. The quality of transmission satisfies all requirements of the Argentinian administration and the CCITT even without a radio program compandor, for r-f transmission in the coaxial network only requires the use of the middle supergroups, which have very low basic noise. Radio program compandors will be recommendable when the system is equipped to capacity.

The Z 12 system (12 telephone circuits per side circuit), which has proved its value over many years both at home and abroad, is used on the unloaded carrier star quads in the interstices of the coaxial cable. As it is also designed to be used for linking up small local stations, the administration attaches particular value to modest space

Fig. 7 Unloading transmission equipment in Buenos Aires

requirements, a demand that is well met by the terminal cabinet with 36 telephone circuits.

Supplementary equipment

Santa Fé is linked with Paraná on the other side of the Paraná River, with its highly fluctuating water table and large flood area, by the FM 60/2000 radio system (frequency modulation, 60 telephone circuits in r-f range around 2000 mc). Reliable communication is secured with a transmitting power of about 5 watts and parabolic dish antennas 6.5 ft in diameter mounted on grid masts.

One full standby channel and an automatic changeover feature insure uninterrupted operation whenever trouble develops in the equipment assigned to the regular channel.

Especially in sparsely populated areas, the Argentinian power current networks are in many cases heavily overloaded. Considerable voltage fluctuations must for this reason always be anticipated. This necessitates the use of voltage regulators. To safeguard operation in the event of a power outage, each station is equipped with a standby power supply. The changeover from regular to standby equipment is effected automatically without any interruption in radiocommunication. In the event of long power outages, Diesel generators or station batteries operating with converters take over the emergency powering of the stations. In places that do not have a power current network, two Diesel alternators are used in turn.

At the stations along the coaxial route, the power for the remote powering of the threephase generators is drawn from continuously running flywheel converters, which are usually driven by mains-powered threephase motors. When power outages occur, the mass of the flywheel serves as a power storage for overcoming the starting time of the Diesel generator (2 sec) and, during normal operation, for equalizing short-time voltage fluctuations.

The operational supervision of such a vast communications network demands a large quantity of specially chosen measuring equipment. Here again it was possible to meet the requirements of the Argentinian administration in every respect.

Since all the equipment was drawn from the same supplier and all the work performed under the same supervisors, the Argentinian administration has an effective guarantee for the proper interoperation of all the equipment used throughout the new long-line network.

High-voltage HRC Fuses with Optimized Grading of the Fuse Wire

By Hans Bitter

High-voltage HRC fuses (designation HH), shown in Fig. 1, interrupt the circuit quickly, thereby limiting the short-circuit current, reducing its duration to a few milliseconds and its magnitude to a small fraction.

In spite of their simple and space-saving construction, the high-voltage HRC fuses have excellent interrupting characteristics. In the porcelain tube of these fuses, which has a volume of little more than 1 dm^3 (61 cu.in.), the most intensive arc quenching process known in practice takes place.

Reliable short-circuit interruption without voltage surges

When the fuse wires of the HH fuses vaporize due to the thermal effect of the short-circuit current, an arc is drawn which is intensively cooled in the tightly packed quartz sand filling. The fault arc has such a high non-inductive resistance that the short-circuit current is greatly attenuated long before it reaches its crest value.

The resistance which is now suddenly cut into the path of the short circuit when the fuse wires blow is proportional

to the length of the fuse wires. Therefore, the longer the fuse wire is, the more reliably the arc will be extinguished. The current characteristic shows that the short-circuit current drops positively and rapidly to zero after the melting current peak (Fig. 2*a*). The design of the HH fuses seems at first to be very simple, namely, the fuse wire should be made as long as possible.

However, the sudden interruption of the current produces switching surges which are also proportional to the length of the fuse wire. In order to keep these voltages low and avoid dangerous surges, the designer would actually now have to apply the principle that the fuse wire should be kept as short as possible.

A mere glance at the hump in the current curve after the melting-current peak (see Fig. 2*c*) reveals the weakness of such fuses: the arc extinguishing effect is too low, with the result that the short-circuit current often continues to flow after passing through zero. These difficulties can be overcome by using the "graded" fuse wire which is at the same time both long and short. This fuse wire has a great effective total length which is subdivided into several sections of various cross sections (Fig. 2*b*).

When a short-circuit current is interrupted, an arc is drawn over the entire length of the fuse wire. In this way the graded fuse wire has the effect of a long fuse wire with regard to positive arc extinction. It has, however, the characteristics of a short wire with regard to the resulting surges. Since the individual sections of the graded fuse wire have different melting times owing to their differing cross sections, only one part of the graded fuse wire is disintegrated at a particular moment in the melting process and the switching surges are kept correspondingly low. The graded fuse wire therefore combines the advantages of both the long and the short fuse wires and eliminates their respective disadvantages. The new graded fuse wire ensures positively that twice the crest value of the rated voltage – the limit laid down by new VDE Regulations for the admissible switching surges – is not exceeded.

Controlled conversion of energy in the fuse

During the rupturing process – consisting of the melting of the silver fuse wires and the extinction of the arc – electric energy is converted into heat in the fuse. The shape and dimensions of the fuse wire have an influence on the thermal stress to which the HH fuse is subjected. Thus the design measures taken to limit the switching surges increase the heat generated inside the fuse[1]. Several stages of development and long series of tests were necessary before the graded fuse wire received its present optimized form, which makes for innocuous switching surges with a minimum of heat generation.

1 Bitter, H.: Einfluß der Bemessung des Steuerschmelzleiters auf die Größe der Löscharbeit bei HH-Sicherungen. Siemens-Zeitschrift **32** (1958) pp. 39 to 43

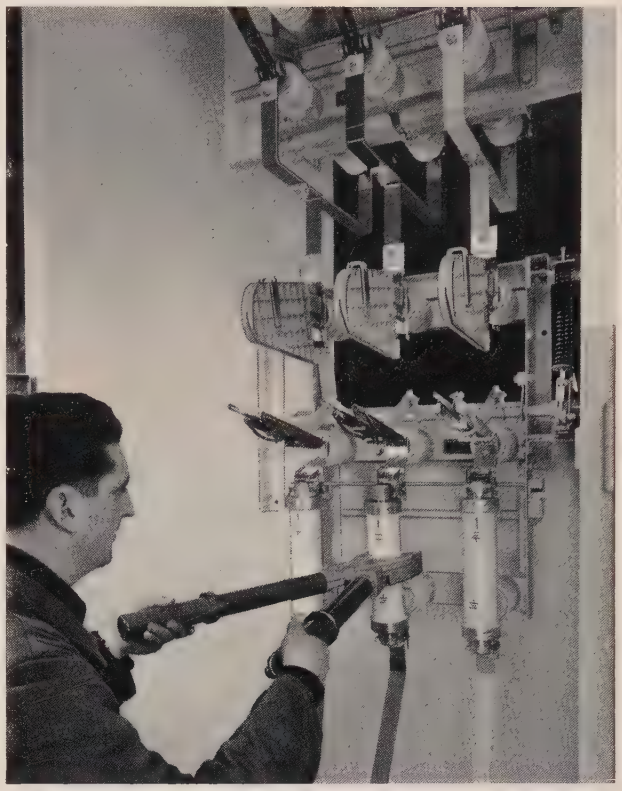


Fig. 1 HH fuses on a load-break switch

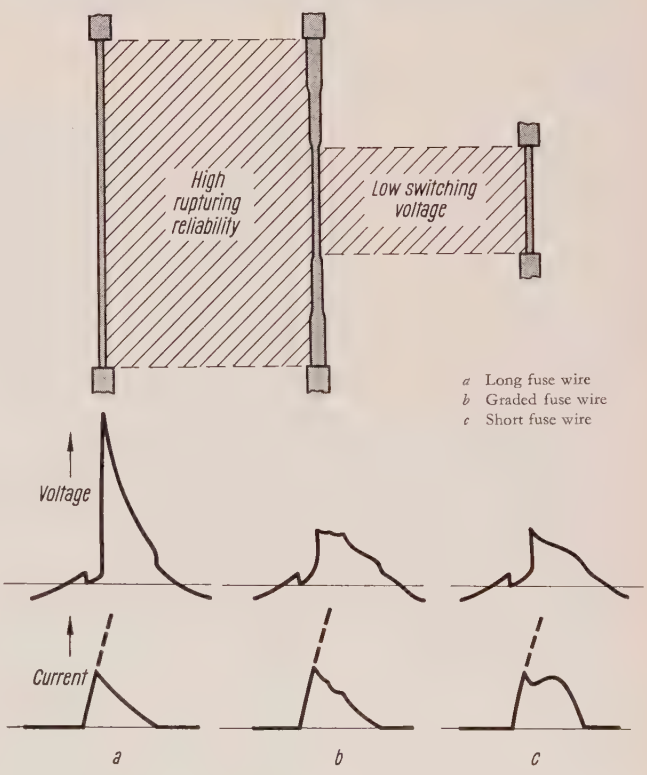


Fig. 2 Voltage and current characteristics of high-voltage HRC fuses with fuse wires of different shapes

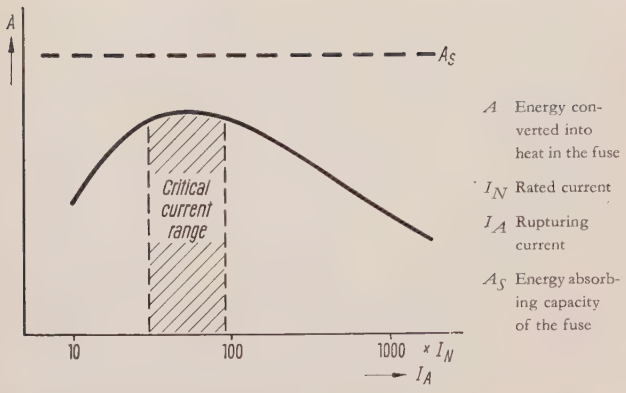


Fig. 3 Thermal stressing of the HH fuse

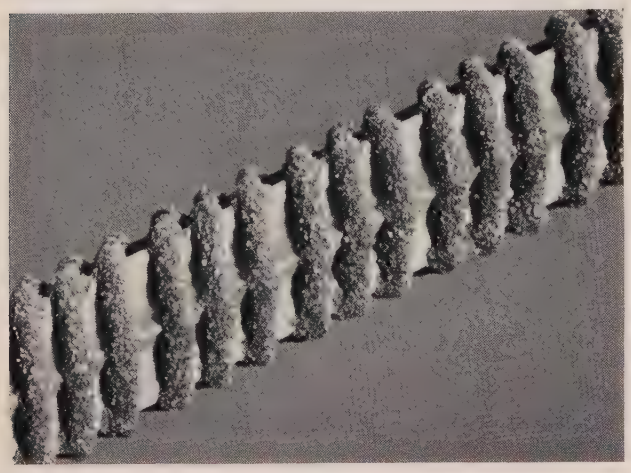


Fig. 4 Grub-like melts in an HH fuse after blowing at critical current

The maximum thermal stress over the entire operating range of the HH fuses does not coincide with the maximum rupturing current (Fig. 3). On the contrary, there is a critical current range with the maximum of energy conversion which was measured at approximately 50 times the rated current. When higher currents are interrupted the fuse is subjected to considerably less stress. The graded fuse wire operates with such a low heat generation that the HH fuses are not endangered even in the critical current range. The thin, grub-like melts still clearly separate after the blowing of the fuse show that the energy absorbing capacity of the fuse has not yet been fully used up (Fig. 4). The rupturing capacity is therefore in no way dependent on the thermal stress. A limit is only reached with extremely high rupturing currents with a high rate of current rise when the body of the fuse is physically destroyed by the sudden vaporization of the fuse wires. This limit is so high, however, that it is generally not necessary to determine the short-circuit capacity at the place of installation when selecting the high-voltage HRC fuses. Most of the values in the following table are not the limit values of the rupturing capacity but merely the maximum values measured in tests:

Rated voltage	Rated current range	Rupturing capacity
3 kV	6 to 200 A	400 MVA
6 kV	6 to 150 A	700 MVA
10 kV	6 to 100 A	1,000 MVA
20 kV	6 to 40 A	1,000 MVA
30 kV	6 to 40 A	1,500 MVA

Call Allotting in Switchboard PABX's

By Erika Behlendorff and Franz Kappl

Persons telephoning business organizations are commonly apt to judge their efficiency by the way their calls are handled by the switchboard attendant. Thus the first mark of efficiency is that calls should be answered without delay. PABX technology is for this reason required to provide that any call arriving at a PABX switchboard can be answered if a switchboard position is free, and that waiting calls will be allotted in the order of their arrival to switchboard positions as they become free.

The automatic allotting circuit (Fig. 1, right) described meets these requirements to perfection: calls are allotted to switchboard positions in a systematic sequence by access selectors; if all the switchboard positions are busy, the calls are routed to a call park, from where they are passed on to the switchboard one at a time. This arrangement permits the equal distribution of traffic loads among all switchboard positions and the assignment of switchboard attendants to duty in accordance with the changing volume of traffic; calls that have to wait are answered at the earliest opportunity and thus with a minimum of delay.

The more trunks there are, the greater will the advantages of this allotting technique be appreciated, for it is here that the disadvantages of the current practice of connecting trunks in parallel to several switchboard positions become apparent: switchboard attendants become so confused by the many call indications that they are unable to remember the sequence in which calls

arrive. Efforts are made to remedy this by dividing the trunks – and hence the switchboard positions – into groups (Fig. 1, left). Once this is done, however, the attendants of one group are no longer able to help out those of another.

In cordless switchboard PABX's with inward dialing to extensions the adoption of call allotting is practically a must. If the majority of outside callers dial straight through to extensions, correspondingly fewer switchboard positions are required. In the case of PABX's without call allotting facilities, on the other hand, the quantity of call indications at switchboard positions will be proportionately greater and it so becomes even less probable that switchboard attendants can cope with the traffic.

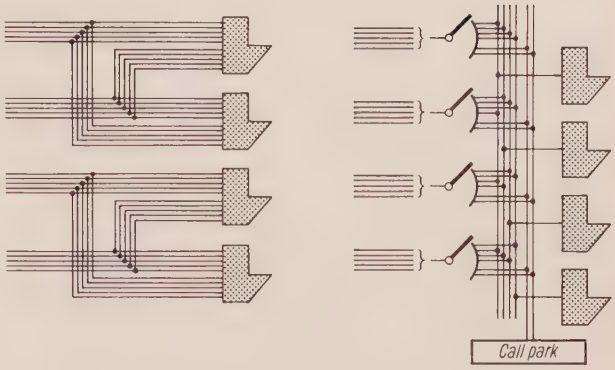


Fig. 1 Distribution of traffic on incoming trunks among several switchboard positions by connecting the positions in parallel in pairs (left) and by call allotting through access selectors, with any call able to reach any position (right)

Layout and operating principle of allotting circuit

The trunks of cordless switchboard PABX's with call allotting facilities are not run directly to the switchboard positions (Fig. 2). Instead, each position is assigned several – usually five – access relay sets that can be reached from any trunk relay repeater by way of access selectors (Fig. 3). The access relay sets of a switchboard position are used in successive order, but only after the preceding call has been answered. This does not mean that the previously seized access relay sets of the respective position must have already been released: these remain held at least until the wanted extension answers. If each switchboard position is assigned five access relay sets, it will seldom, if ever, occur that a switchboard attendant cannot be reached because all five access relay sets assigned to her position are occupied.

If there are no remaining possibilities for a call to be answered, it is routed to a call park. A transfer circuit likewise routes all subsequent calls to the call park and insures that they are not routed out of turn directly to the access relay set of a switchboard position that has just become free. As soon as a ready-to-answer signal comes in from a position circuit, the call park releases whichever

Fig. 2 Switchboard of PABX with inward dialing and call allotting in Volkswagen factory at Wolfsburg. Seen in the background are some of the racks accommodating the EMD switches

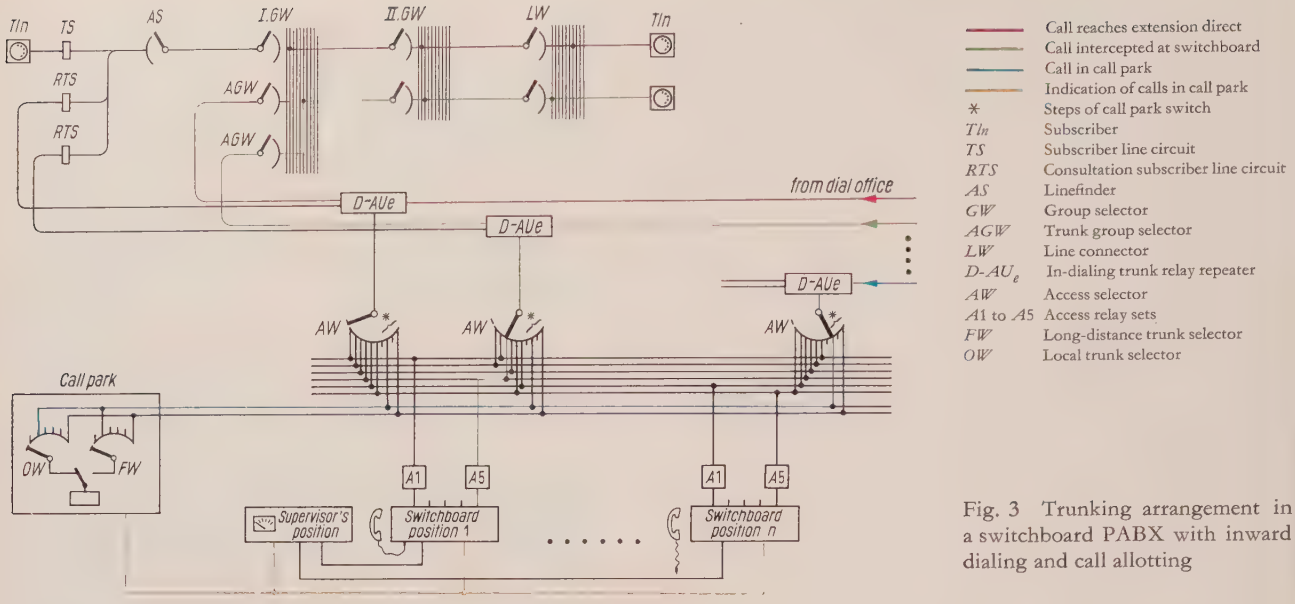


Fig. 3 Trunking arrangement in a switchboard PABX with inward dialing and call allotting

call arrived in the park first. Long-distance calls are treated on a priority basis. Thus first of all the long-distance selector in the park sets to that particular storage step at which the first long-distance call arrived and releases the respectively set access selector. This now rotates to the idle access relay set. If there are no more long-distance calls in the call park, the local trunk selector routes the other calls in the park to switchboard positions as they become free. A "reminder" lamp burns at all switchboard positions and at the supervisor's position for as long as any call remains in the call park. The guarding period between the answering of a call and the arrival of a new call at the same switchboard position is adjustable between 20 and 40 sec so that the traffic load can be distributed evenly among the various positions during slack periods. When calls are in the call park during heavy traffic, the guarding period is terminated prematurely when a call is switched through to the wanted extension.

Operating features

In the call allotting technique the switchboard positions form a full-access group, i. e., any call has access to any switchboard position at any time. Parked calls are passed on in the order of their arrival to switchboard positions as they become free. The primary advantages offered by this technique are thus short delay times and the optimum distribution of traffic among the switchboard positions.

Call allotting also introduces a number of other advantages:

Shorter delay times directly reduce the load on trunks, which in turn reduces the number of calls that encounter ATB conditions; trunk efficiency is consequently enhanced.

Apart for their conventional "common buttons", the switchboard positions (Fig. 4) are equipped with only five strips of lamps and buttons, representing the five access relay sets. This presents great functional clarity in the case of PABX's with inward dialing to extensions and appreciably simplifies the duties of switchboard attendants.

The flexible distribution of calls irrespective of the trunks over which they arrive makes it possible for any desired switchboard position to be shut down during slack periods. The number of switchboard positions occupied is readily adaptable to the traffic offered, and calls arriving outside of office hours can be routed to a night-service position. If an appropriate supplementary device is added, calls arriving outside of office hours can, as an alternative, be routed to a trunk-access extension.

Switchboard PABX's with a call allotting feature can also be expanded at any time without the switchboard positions or other equipment having to be modified in any way.

In extra-large switchboard PABX's it may be useful to equip one switchboard position with additional indicators which show, say, the number of calls in the call park, and the operating condition and traffic load at the various positions, etc. This supervisor's position is thus furnished with a clear picture of the flow of traffic and the supervisor can at all times institute appropriate measures such as coordinating the duties of switchboard attendants, assisting them in their duties, or taking care of calls for special classes of information, etc.

Call allotting facilities can also be incorporated in existing PABX's without the switching equipment having to undergo any form of modification.

Effect on traffic

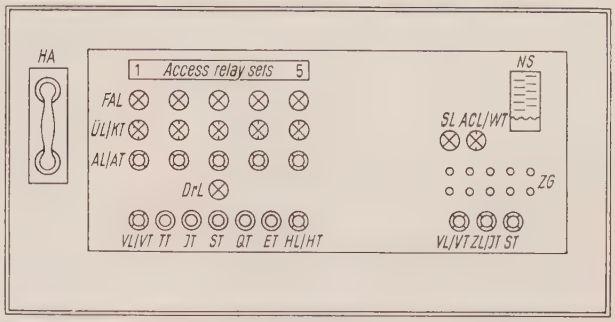
The effect of call allotting on the grade of service in answering incoming trunk calls is best demonstrated by

the number of calls that have to wait, say, 5, 20, 40 and 60 sec to be answered. Calculations covering these portions of the traffic as referred to the total number of calls are based on the extensive investigations into mathematics and traffic theory undertaken by A. K. Erlang, C. D. Crommelin and others. Practical examples for the planning of dial offices and PABX's are given by H. Störmer[1]. It is generally assumed that delayed calls are answered by a full-access group in the order of their arrival. Crommelin assumes the time taken by operators to answer calls to be equal for all calls, whereas Erlang assumes it to be subject to an exponential distribution. Since its length actually lies between these two marginal cases, the above table gives the mean values of both results.

Assume that a switchboard PABX has, say, 60 trunk relay repeaters for incoming traffic which, as an almost full-access group with a loss V of 1%, carries about 42 erlangs. If we take the average holding time to be 3 min and assume that 50% of incoming calls reach extensions without interception at the switchboard, there remains an average of 420 calls per busy hour that still have to be answered at the switchboard and transferred to wanted extensions. Since an average of 20 sec will here be required per call, the traffic that has to be handled directly at the switchboard will be 2.3 erlangs. Let it be assumed in the interest of simplicity that all calls are answered on a no-priority basis, with long-distance calls treated in the same way as local calls. The actual manhours per position, expressed as a percentage, is denoted α and should not as a rule exceed 60 to 70%.

In Table 1 a comparison is shown between the percentages of calls parked in switchboard PABX's with call allotting facilities and those of calls parked in PABX's without. To complete the picture, figures are given not only for the 60-trunk PABX already mentioned

1 Störmer, H.: Verkehrstheoretische Grundlagen für die Planung von handbedienten Vermittlungsanlagen. Archiv der elektrischen Übertragung **12** (1958) pp. 119 to 126



⊗	Lamp	*VL/VT*	Connect lamp/connect button
◎	Pushbutton	*TT*	Splitting button
◎	Illuminated pushbutton	*JT*	Pulse stop button
⊗	Illuminated rotary button	*ST*	Clearing button
		QT	Entering button
		ET	Grounding button
		HL/HT	Attendant circuit lamp/attendant circuit button
FAL	Long-distance call lamp	*SL*	Guard lamp
ÜL/KT	Supervision lamp/ holding button	*ACL/WT*	Call supervision lamp/bell button
AL/AT	Call lamp/ answering button	*ZL/JT*	Keysender lamp/pulse stop button
DrL	Reminder lamp	*NS*	Dial
		ZG	Keysender

Fig. 4 Face plan of switchboard position for switchboard PABX's with call allotting

but also for one with 90 trunks. For PABX's with call allotting facilities (red print) the table shows a requirement for only four switchboard positions in the case of 60 trunks, and only six positions in the case of 90 trunks. More positions than this would represent an over investment.

It will be seen from the table that positive advantages are to be secured through the introduction of call allotting: whereas in the case of the 60-trunk PABX with four switchboard positions and no call allotting facilities 4.7% of the calls, representing about 20 during the busy hour, have to wait longer than 40 sec to be answered, the introduction of call allotting reduces this percentage to 0.5%, representing only about two calls that have to wait longer than 40 sec. Even if the PABX without call

Quantity of trunks	Quantity of switchboard positions	Occupancy α %	Percentage of calls having to wait longer than 5 sec %	20 sec %	40 sec %	60 sec %
60	4 in one group	59	16.6	3.0	0.5	0.1
	4 in two groups	59	34.4	13.7	4.7	1.9
	6 in three groups	39	15.5	3.9	1.0	0.3
	6 in two groups	39	7.9	1.0	0.2	0.03
90	6 in one group	62	12.3	1.6	0.1	0.01
	6 in three groups	62	38.0	16.4	6.1	2.6
	8 in three groups	46	15.2	3.2	0.7	0.2
		with call allotting	without call allotting			

Table 1 Grade of service in answering calls arriving over 60 or 90 incoming trunks, as the case may be, with 50% of the calls dialed straight through to extensions in the case of switchboard PABX's with and without call allotting

allotting should be expanded from four to six switchboard positions connected in parallel in pairs, 1% of the incoming calls would still have to wait longer than 40 sec to be answered, and the figure of 0.2% would not be reached unless these six positions were arranged in two groups of three.

For 90 incoming trunks the appropriate values are 6.1% without and 0.1% with call allotting. For the PABX with call allotting an expansion of the switchboard positions from six to eight will not secure any advantage at all over the PABX with call allotting and only six switchboard positions.

The calculating results clearly demonstrate the practical benefits of call allotting. The outlay for equipping or modifying a switchboard PABX for call allotting is a single investment that is more than balanced out by continual savings through the better utilization of trunks, a possible reduction in the number of switchboard positions, and, in particular, through lower personnel expenditure.

New Receivers for Centralized Multi-service Control

By Walter Henning

An important object of the development work in the field of centralized multi-service control was to design the receiving equipment for the various single-frequency control signals so that, on the one hand, it operates in response to a relatively low audio-frequency voltage and, on the other hand, is insensitive to interferences of shorter or longer duration from the 50-c/s power transmission system. This ensures effective protection against false tripping. In view of the effect on the economy of the entire carrier control system, it was, however, essential that this improved technical performance of the new receivers over the former apparatus be achieved without involving a considerable increase in expenditure.

The newly developed receivers of the Siemens centralized multi-service control system meet all these requirements, and this applies to both the simple call receiver and the multi-service motor-operated receiver. The call receiver (Fig. 1) is used to alarm the public services such as fire brigade, police, civil defence, etc. It is also suitable for transmitting, in addition to a normal alarm signal, definite code signals from the central control station to a distinct group of persons or for transmitting various states of alert.

This simple call receiver has a resonant input circuit, tuned to a control audio-frequency of about 2,000 c/s, which receives the incoming audio-frequency impulses, amplified in a transistor, through a selective switching circuit fitted with a time-pulse receiving relay and an impulse storage unit. This impulse storage unit is so designed that the initiation of the call signal and the reproduction of the code signals transmitted depends on a definite number of audio-frequency impulses being received in a definite time. Impulse trains of different character or single impulses or even continuous signals of the control frequency due to interference from the 50-c/s system or from the parallel operation of motor-operated receivers, do not cause the resonant call receiver to operate, thus giving it a degree of selectivity which for such a simple design is remarkable. In spite of the high safety provided against false tripping, the response time of the call receiver is only about 1 second.

As distinct from the alarm of public services, motor-operated multi-service receivers (Fig. 2) are used for the remote control of street lighting circuits, two-rate electricity meters, hot-water storage heaters and similar small power consuming apparatus connected to a power supply system; depending on their setting, these only respond to a definite combination of impulse signals transmitted from the central control station. This makes it possible to transmit a wide range of control signals with a single frequency within a certain district of the system, and to have them evaluated by the groups of receivers set to operate in response to the particular signals. The individual motor-operated receiver can be set to a definite control signal or to a definite signal combination in a simple way by alternatively changing over five insulated levers arranged on the contact plate. For each receiver there is available a total of 30 different signal combinations. In addition to this, three switching groups can be set up for the entire system so that a Siemens centralized multi-service control system can transmit and interpret up to 90 double signals within a power system or system area.

The motor-operated receiver has the same tuned input circuit as the simple call receiver, but is additionally fitted with a face plate with contact segments arranged on a circle, over which a rotary contact arm is moved by a synchronous motor upon the arrival of a control signal. To prevent false operation as a result of transient interference impulses or audio-frequency call signals,

this motor is started up only after a minimum time delay of the starting impulse of 1 second, and moves the rotary selector arm to the first contact segment. The motor is then switched off and is started again in synchronism with the signal transmitter and the other receiver motors at the end of the starting impulse, thus causing the selector arm to complete its operation proper.

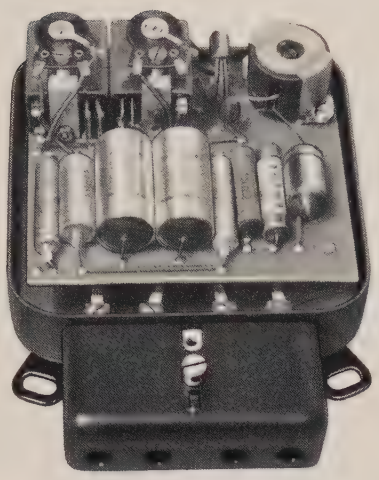


Fig. 1 Call receiver with cover removed

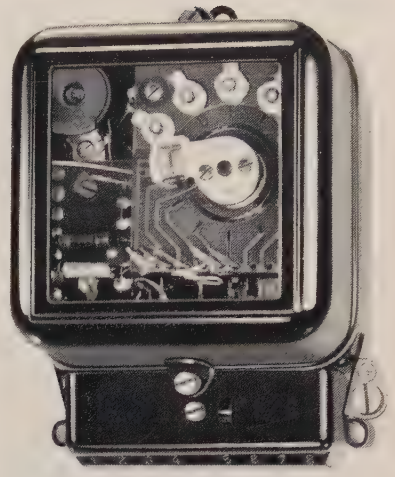


Fig. 2 Motor-operated multi-service receiver

At the beginning of the rotary motion of the selector arm a capacitor is charged locally in the motor-operated receiver. Its charge can be used for operating the switching relays associated with the individual receivers at the end of the incoming control impulse train only when the combination of control signals received corresponds to the insulated-lever combination set in the particular receiver. Any deviation from this combination of the impulse train received, due to other control signals or an additional interference impulse, effects a premature discharge of the switching capacitor, thus preventing false operation. Interference impulses of a frequency other than that of the coded signal are by-passed in the input filter circuit of the receiver.

The duration of the transmission of the individual switching signal is approximately 15 seconds with the Siemens motor-operated multi-service receiver. The receiver is supplied with one or alternatively with two switching relays, each of which has a power contact with a breaking capacity of 400 W. Both the call and motor-operated receivers contain time- and service-proved components which are standard in communication engineering, thus ensuring a high degree of reliability in operation with a minimum of maintenance.

The high degree of selectivity inherent in the motor-operated receiver makes it also suitable for remote control operations which (e. g. the remote control of network protectors) are far beyond the scope of normal applications of the centralized multi-service control system, thus opening up new fields to this type of carrier control. In the same system, the call and motor-operated receivers can be operated in parallel at the same sending frequency.

The Siemens multi-service receivers are generally used in low-voltage systems with decentralized audio-frequency infeed. The control power required for operating the receivers is not supplied to the medium-high-voltage systems and transmitted on to the low-voltage system but is fed from the central control station over telephone cables or other transmission channels. This energy which is in the form of audio-frequency impulses is then passed to transmitter amplifiers, located at the load centres of the low-voltage systems.

The audio-frequency energy is generated at the control station by means of a transistorized audio-frequency oscillator unit which requires very little space and which operates with a frequency accuracy of 0.1 per cent. The required transmission power is then only 0.005 to 0.01 per cent of the transformer capacity installed in the low-voltage system. The injection is in each case effected between the three-phase conductors on the one hand and the neutral conductor on the other, thus preventing three-phase loads, particularly three-phase capacitors, from impairing the propagation of audio-frequency signals. The effect on the centralized control system of single-phase power factor corrective capacitors used in conjunction with fluorescent lamps can, if necessary, be obviated through the medium of suitable circuit arrangements. The in-phase infeed of the audio-frequency eliminates the need for line traps against other systems. Low-voltage transformers are provided with audio-frequency traps on account of the low zero-sequence reactance of the neutral conductor.

The above described type of infeed for which connections must be provided between the control station and the individual load centres of the system or transformer substations, makes it possible to reduce to a minimum the normally considerable expenditure required for the central audio-frequency generating plant, including the coupling members for feeding the audio-frequency into the medium-high-voltage system. By reason of the low sending energy required at the control station the centralized multi-service control system can be enlarged in a simple way or extended to include new areas of the system.

Siemens Wernerwerk für Telegrafen- und Signaltechnik

By Gerhard O. Zimmermann

More than a century ago communications engineering was revolutionized by the invention of electrical telegraphy. The pointer telegraph of 1850 has since been gradually transformed into the teleprinter, which has become a standard item of office equipment in all modern businesses.

The Siemens organization was originally founded as a telegraph factory and right down to the present day telegraphy is still one of its most important branches of activity. The transmission of signals in the form of pulses has proved its effectiveness not only in telegraphy but also for indication and control. This digital technique also forms the basis of electronic information processing. Telegraphy, indication, control and information processing are the principal branches of activity of the Siemens Telegraph and Signaling Division (Wernerwerk für Telegrafen- und Signaltechnik).

Teleprinters, transmission systems and switching centers for public and private telegraph networks, as well as the associated relays, are built in large, modernly equipped workshops in Berlin and München. Uniformly high quality standards are guaranteed for all products by quality control checks conducted at large test setups specially developed for this purpose.

The indication and control sector covers the development and production of traffic control equipment (especially for public highways), fire detection equipment,

Fig. 1 The Telegraph and Signaling Division is a separate building within a vast complex of Siemens factories in München. It houses the Technical Planning Departments and Sales Departments with offices covering a total area of more than 65,000 sq.ft. It also contains training rooms in which Siemens personnel and other trainees are instructed in the use of equipment. Next to this building a second building is at present being erected to accommodate the Planning Department and Sales Department for data processing systems.

Fig. 2 The development, planning and production of railroad signaling equipment is concentrated at the Braunschweig factory, which is able to look back upon many decades of activity in this field. The photograph shows the assembly of track-diagram interlockings from standard panel sections in congruence with the individual track diagrams of the stations for which they are intended

and burglar alarm equipment. An important position is also occupied by the railroad signaling technique. In a special factory in Braunschweig interlockings of all sizes, automatic train control equipment, and also all the other facilities required to insure the safety of trains are developed in modern laboratories and produced in well-equipped workshops.

Suitable electronic data processing systems are being developed and produced for information processing, which is assuming growing importance in business life. A special Siemens computing center is available for the solution of mathematical and accounting problems. Information processing is likewise making more and more headway in business management and workshops, where it is finding widespread application for production control.

Combination systems composed of information processing equipment and teleprinter equipment have here yielded extremely favorable solutions, and workshops and production methods have been closely adapted to the given requirements. The illustrations accompanying this report furnish some idea of the many activities of this Division.

Fig. 3 Just as old as telegraph engineering is the relay. Mature production techniques permit the fabrication of supersensitive miniature relays with uniformly close tolerances. The photograph shows a measuring setup where the contact gaps of a miniature polar relay are adjusted by means of a microscope. Only through this type of precision alignment is it possible to maintain the operate values of such relays within the specified narrow tolerances

Fig. 4 Complex equipment such as the teleprinter, in which a multitude of mechanical and electrical operations have to be coordinated, has to go through a thorough test following assembly. Large measuring setups have been developed for such work. In many cases the actuation of a pushbutton is sufficient to initiate the objective testing of the functions and characteristics of a teleprinter to the complete exclusion of all random influences

Fig. 5 Most of the equipment of the Telegraph and Signaling Division is produced in factories in Berlin, München and Braunschweig. All rooms throughout the factories are designed according to the most up-to-date concepts and permit precision work under conditions of extreme cleanliness. The photograph shows a room containing automatic laths in a Munich factory in which precision parts are fabricated for teleprinters

Fig. 6 Control console of computing center of Telegraph and Signaling Division. A Siemens 2002 data processing system is here available to Siemens engineers and customers for the solution of all types of technical and accounting problems

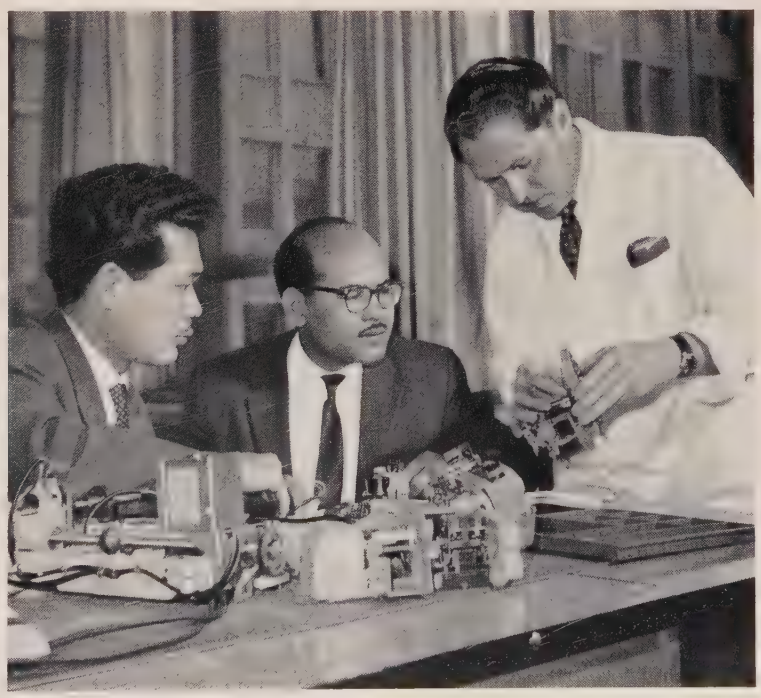


Fig. 7 The products of the Telegraph and Signaling Division are exported to all parts of the world. Assembly and maintenance are today largely entrusted to engineers and technicians native to the country of the customer. A staff of training personnel is available for instructing trainees from abroad in the handling of our equipment. The photograph shows two Indonesian engineers watching the disassembly of a teleprinter into its component parts. The functioning of the parts and the principles of assembly are explained at the same time

NEW EQUIPMENT

Long-Distance, Telephone-Telegram and Information Desks for Tehran

BY ALEX SCHÖLLER

The expansion and automatization of numerous local telephone networks in Iran [1, 2] is expected to be followed by a lively increase in telephone traffic. This applies in particular to traffic between Tehran and the industrial centers along the Golf of Iran, and with Mashad, Ghom and other places of pilgrimage elsewhere in the country. A further reason for the growth in telephone traffic is that Iran handles a considerable amount of transit traffic between Europe and the Middle East, the Near East and the Far East.

The Iranian PTT decided for this reason also to expand its long-distance network, and long-distance switchboards operating on the F 36 system are now being installed along with the new EMD dial offices.

Within the Iranian telephone network, the Tehran longdistance office occupies a position apart. It was set up – along with the radio office, the telegraph office and information desks for the local Tehran network – in a new wing of the PTT Ministry (Fig. 1). This building also houses a large switchboard PABX supplied to the Ministry by Siemens & Halske.

First of all 16 long-distance switchboards were installed at which telephonists trained by the West German Post Office take care of all types of calls (Fig. 2). During the course of 1960 the number of switchboards was doubled and they were arranged in separate groups for incoming, outgoing and transit calls (no-delay and delay services).

Fig. 1 Tehran's long-distance communications building

Fig. 2 Inside the long-distance telephone office

Each switchboard assigned to handling transit calls is additionally equipped with three special cordpairs for through-ringing. With each of these cordpairs it is possible to interconnect two long-distance trunks for a predetermined period of, say, several hours daily for transit calls. The switchboards are equipped with emergency illumination and slave clocks.

On account of the central location of Tehran, not only terminal calls but also countless transit calls are handled at the radio office. Five further long-distance switchboards with 4-wire switching facilities serve for this purpose. Trunks from the radio office to the long-distance office and local dial offices run through 4-wire/2-wire hybrids.

Long-distance information is available to Tehran's telephone users at six desks, while ten switchboard positions take care of long-distance calls. Six positions are assigned to telephone-telegram service. The switchboard operators type out each telegram message on a form, which they then pass on to the telegraph office.

Telephone users are able to reach the police precinct and fire department over an emergency circuit. In certain cases such calls

can be intercepted by holding the occupied switches to allow the origin of the call to be traced [3].

Central test equipment is also connected to the service group selectors. This equipment includes a ringback relay repeater for checking the occupation of an associated telephone installation [3], a dial pulse tester and a level and meter pulse generator, which are primarily used by troubleshooters.

The eleven local information desks are provided with a card index of names recorded in Iranian and another with names in other languages. A card index of directory numbers is to be added later. The pivoting indexes have a capacity of 50,000 names each and are so arranged that each information desk has access to two indexes. When a call arrives at a wrong desk, it can be transferred to the right one or to the supervisor, who also takes care of special information calls.

Operators at the information desks are also free to initiate metering: if a call for information concerns a subscriber who is listed in the telephone directory, the operator initiates metering by pressing a button.

Installed in the long-distance office are 14 coinbox telephones for local calls. They have two tariff zones and are adapted to accept one-rial coins; they are also compatible for future direct distance dialing.

Another room has 48 telephone booths for the public to conduct calls established by long-distance switchboard operators. The operators establish the connections and also collect the fees due. An advance fee covering three minutes of conversation has to be paid when such a call is booked; inside the booth a warning lamp lights up as the end of this period approaches.

An automatic power supply plant has been installed to operate the telephone equipment [4]. It is dimensioned for 60 v d-c and a power consumption of up to 400 amps.

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MISCELLANEOUS

Waterwheel Generators for Surinam (South America)

By Karlfried Schäfer

Surinam lies on the north coast of South America and was formerly known as Dutch Guiana. It is here that the Brokopondo hydroelectric power station is to be erected for a total installed capacity of 210 MVA and a maximum output of 240 MVA (Fig. 1). The order for the power station has been placed with Siemens-Schuckertwerke by the Aluminum Company of America (Alcoa) for its subsidiary, the Suriname Aluminum Co.

The Alcoa is one of the largest aluminium producing undertakings in the world and procures most of the basic material bauxite from Surinam. Since the bauxite found there is of high grade, and since Surinam has unexploited water power potential, it was quite natural that consideration should be given to the erection of a plant to process the material on the spot. Now, with the participation of the government of Surinam, plans have been drawn up for the erection of an aluminium smelting works, a hydroelectric power station, high-voltage lines and a system of roads and installations. This project will make an important contribution to the furtherance of the economical development of the country.

It is intended to build a dam across the River Surinam about 100 miles upstream from the mouth and to locate the power house at the foot of this (Fig. 2). The power house will accommodate six generating units each consisting of a vertical-shaft propeller turbine and a three-phase synchronous generator. The available head is approximately 135 ft. The installation of six generators permits the load to be so distributed that the propeller turbines are also able to operate with a high efficiency in the upper load range. The turbine construction is simplified by the use of fixed blades.

Each pair of generators is coupled to a common generator transformer. A 161-kV double-circuit overhead line transmits the power

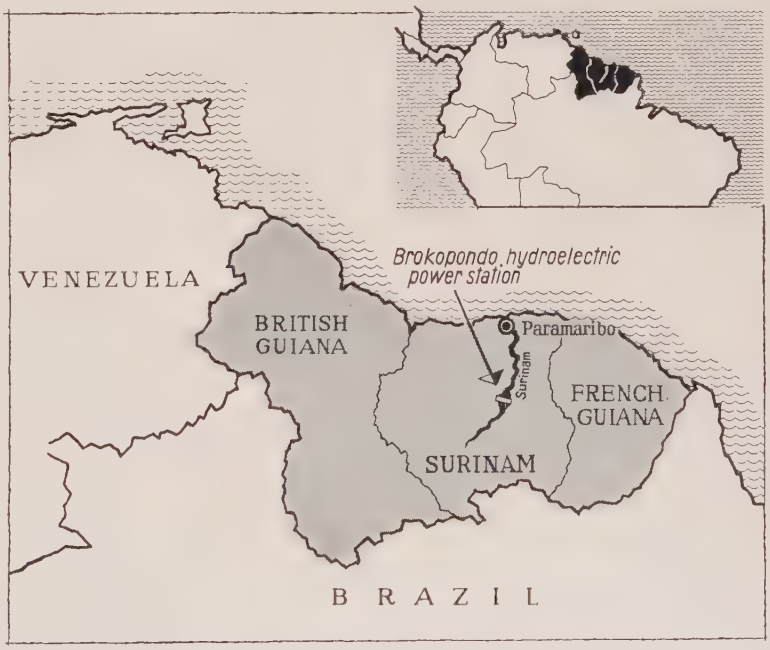

Fig. 1 Location of the future Brokopondo hydroelectric power station in Surinam

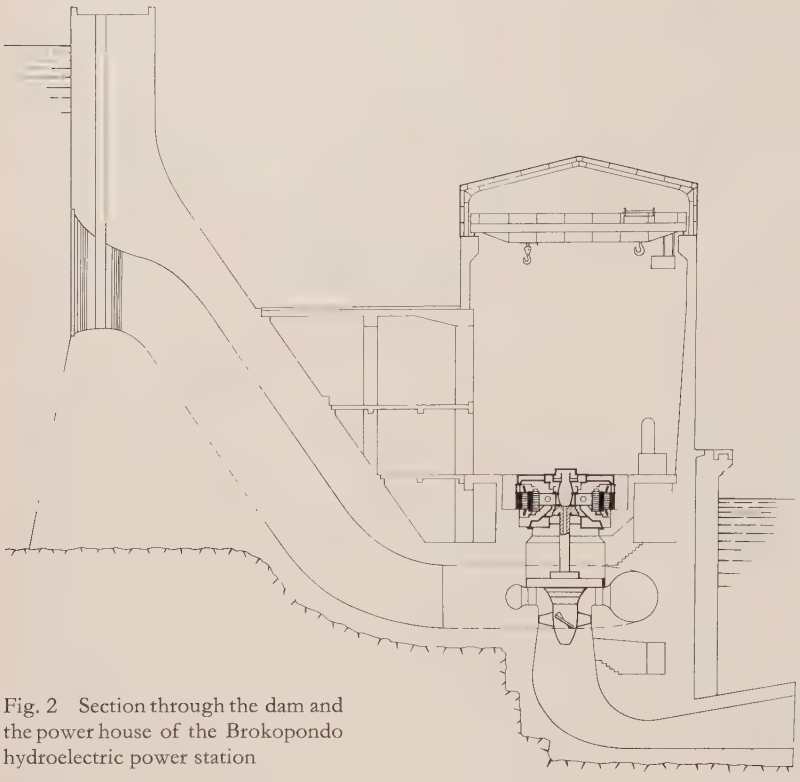

Fig. 2 Section through the dam and the power house of the Brokopondo hydroelectric power station

from the outdoor switching station to the aluminium smelting plant some 45 miles away and other 161-kV radial lines serve for the local electricity supply.

Each of the six generators has a rating of 35 MVA at a power factor of 0.857, the maximum continuous rating being 40.25 MVA. The generators are designed for a rated voltage of 13.8 kV and a frequency of 60 c/s. Despite the relatively high speed of 240 r.p.m., the generators are of the umbrella type of construction. The generator is arranged under the turbine hall floor and the combined thrust and guide bearing is located under the rotor. The thrust block is integrally forged with the shaft. To facilitate inspection, provision has been made to lower the centre section of the thrust bearing with the thrust shoes. The oil is automatically circulated by the pumping action of the bearing which is cooled by external water/oil coolers. The generator rotor is of the laminated-rim type. A large number of sheet-steel segments are clamped together by bolts to form a floating ring which is then shrunk onto a welded hub. In order to save time and space during erection, the laminated rims will be stacked in the works, leaving only the field poles to be fitted on site. The rotor hub is flanged onto the upper end of the shaft above the thrust bearing. This arrangement permits the rotor to be removed for inspection without changing the position and alignment of the shaft. The shaft is not sectionalized and down to the turbine runner forms a single piece. The generator stator is designed in two halves, the core being supported by a sturdy welded construction. The stator winding, which is very robust and of the transposed-bar type, is insulated throughout with MICALASTIC*. This synthetic resin insulation is particularly suitable for damp climates and for the tropics.

The induction motor of the separately installed high-speed exciter set is supplied with power by a constant-voltage auxiliary generator mounted on the main shaft above the rotor. The omission of exciters on top of the main generator not only reduces the height but also improves the response of the excitation system. The fieldcurrent for the exciter is supplied by a time-proved two-stage magnetic-amplifier voltage regulator of standard design.

As is usual, the generator equipment also includes the air coolers arranged on the rim of the stator, the permanent-magnet generators for feeding the turbine governor and the supervisory equipment.

* Trade-mark

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SIEMENS

U.D.C. 621.311.22(46)

GÜNTER EIFERT

The Badalona (Spain) Steam Power Station

10 pages, 7 figures, 1 table

Siemens Review XXVIII (1961) pp. 35 to 44

The new steam power station is the largest and the most modern station in Catalonia and is primarily intended for service during the dry periods. When the hydroelectric power stations in Catalonia have sufficient water supplies available to cover the power requirements, the steam power station can be operated as a synchronous condenser.
In the first two stages of construction the power station has been provided with two 34-MW turbo-sets and one 69-MW turbo-set.
A description is given of the construction and layout of the steam station.

SIEMENS

U.D.C. 621.315.212.4(82)

RUDOLF ZÖCKLER† AND WERNER SCHUBERT

Coaxial Cable for Argentina

4½ pages, 5 figures, 1 table

Siemens Review XXVIII (1961) pp. 45 to 49

The electrical and mechanical characteristics of the coaxial cable are described with due attention paid to its gas-pressure monitoring system. The principal guaranteed values are stated. Acceptance tests and the first transmission results obtained with the sections already installed show that the guaranteed values of the cable system are reliably met.

SIEMENS

U.D.C. 621.316.923.1

HANS BITTER

High-voltage HRC Fuses with Optimized Grading of the Fuse Wire

2 pages, 4 figures

Siemens Review XXVIII (1961) pp. 54 to 56

The fuse wire with a graded cross-section combines the advantages of a long wire with those of a short one. It provides a high degree of safety and obviates dangerous voltage surges when interrupting the circuit. Extensive tests carried out on graded fuse wires have produced the optimum design with which the thermal stresses of the HRC fuses when rupturing are reduced to a minimum. The rupturing capacity of Siemens HRC fuses is therefore not limited by the thermal stresses and is well above the usual short-circuit ratings of high-voltage systems up to 30 kV.

SIEMENS

U.D.C. 621.395.341.8

ERIKA BEHLENDORFF AND FRANZ KAPPL

Call Allotting in Switchboard PABX's

4 pages, 4 figures, 1 table

Siemens Review XXVIII (1961) pp. 56 to 60

A new allotting technique for large PABX's and, in particular, for switchboard PABX's whose extensions are directly accessible to outside parties, has been developed. Constructional design, operating principle, service features and traffic-handling efficiency of PABX's with built-in allotting are described and the quality of service with which calls on incoming trunks are answered in the case of PABX's with and without allotting compared.

SIEMENS

U.D.C. 621.313.322-82:621.311.21(8)

KARLFRIED SCHÄFER

Waterwheel Generators for Surinam (South America)

1 page, 2 figures

Siemens Review XXVIII (1961) pp. 67 and 68

In Surinam, formerly Dutch Guiana, the Brokopondo Hydroelectric Power Station with a total generating capacity of 210 MVA (maximum 240 MVA) is under construction. The order for the six vertical-shaft waterwheel generators was placed with the Siemens-Schuckertwerke AG. A description is given of the generators and appurtenances.

SIEMENS

U.D.C. 621.395.5:654.1(82)

LUDWIG GRAF AND GUSTAV HOHL

Transmission Technique in Argentina's Long-Line Communications Network

5 pages, 7 figures

Siemens Review XXVIII (1961) pp. 49 to 54

The new telephone network was established with the V 960 carrier system for coaxial lines, the Z 12 system for star quads, the Z 3 F and Z 12 F systems for open-wire lines, and the FM 60/2000 system for a radio link. Two of the six coaxial lines (one for each direction) are assigned for the transmission of tv programs; tv sound is transmitted over shielded radio program pairs. Radio programs are transmitted by carrier over three adjacent telephone channels. For telegraphy, the 24-channel carrier telegraph system WTS 24 is used. The paper describes the overall communications network and the principal features of the transmission technique employed.

SIEMENS

U.D.C. 621.398:654.93

WALTER HENNING

New Receivers for Centralized Multi-service Control

2 pages, 2 figures

Siemens Review XXVIII (1961) pp. 60 and 61

New types of receivers have been developed for audio-frequency power-line carrier control systems. Alarms for public services, such as fire brigade and police etc., are given by a simple call receiver. For the remote control of street lighting, two-rate meters, hot water storage heaters, however, a multi-purpose receiver with a synchronous motor-driven contact mechanism is employed. Both receivers have a high degree of selectivity and provide for the selection of thirty different control impulses.

SIEMENS

U.D.C. 621.395.722(55)

ALEX SCHÖLLER

Long-Distance, Telephone-Telegram and Information Desks for Tehran

1½ pages, 2 figures, bibliography

Siemens Review XXVIII (1961) pp. 66 and 67

With the establishment of large local telephone networks in Iran – German firms are supplying EMD dial offices for 180000 telephone lines – a long-distance network with Tehran's long-distance office as a focal point is taking shape. The equipment and subscriber services of this long-distance office are here described.

SIEMENS